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THE

GEOLOGICAL MAGAZINE

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No. I.—JANUARY, 1924.

EDITORIAL NOTES.

IT is our sad duty to begin this first number of the new volume with a brief reference to the death on 9th December last of the Rev. Thomas George Bonney, M.A., B.D., Sc.D., F.R.S., Fellow of St. John's College, Cambridge, Hon. Canon of Manchester and Emeritus Professor of Geology in University College, London, formerly Secretary and President of the Geological Society and of the British Association, at the age of 90 years. Professor Bonney must have been one of the oldest, if not the oldest, of British geologists. As, however, he began his geological career somewhat later than some of his contemporaries, his name does not appear in the list given in our last number of living geologists mentioned in the fi st volume of the GEOLOGICAL MAGAZINE. Nevertheless, the present Editor has a distinct recollection of being told by the late Dr. Henry Woodward that at a very early period in the history of the Magazine, within a year or two of the commencement, Professor Bonney came forward with characteristic self-effacing generosity and tided over an awkward financial situation, thus enabling the Magazine to get a clear start on its long career under Dr. Woodward's editorship. It is hoped that an appreciation of Dr. Bonney's geological work, both as a teacher and an investigator, and of his influence on the general scientific thought of his time, will appear in our next number.

* * * * *

CECIL EDGAR TILLEY, Ph.D., of Emmanuel College, has been appointed Demonstrator of Petrology in the University of Cambridge, in succession to Mr. J. M. Wordie, of St. John's College, who has resigned the post owing to pressure of other duties. Dr. Tilley's recent work on metamorphism is no doubt familiar to our readers.

ORIGINAL ARTICLES.

The Carbonaceous Shale or Richmond Formation of Jamaica.

By C. T. Trechmann, D.Sc., F.G.S.

(PLATES I AND II.)

Introduction.

THE Carbonaceous or Black Shale or Richmond Formation of Jamaica is a deposit of considerable importance in connexion with the geological history of the Greater Antilles. R. T. Hill[1] correlates provisionally the Richmond Formation, as he calls these beds, with the Scotland Series of Barbados, the oldest formation in that island, and also with certain of the Tertiary beds of Trinidad. In the present communication I shall endeavour to present some observations on the Carbonaceous Shale Series of Jamaica, together with a description of the fossils I collected in it. This series of deposits consists of a sequence of ferruginous sandstones both coarse and fine-grained, some of them very hard, others when weathered extremely friable; of impure carbonaceous limestones of a very unfossiliferous nature; of grey nodular friable shales often with carbonaceous plant-like remains in them, but scarcely any other fossils; and of coarse conglomerates which seem to occur chiefly in the lower part of the formation.

The interest in the organic remains (which are mostly found among the conglomerates) lies in the fact that some of them are derived while others are contemporaneous. The former comprise fragments from the Cretaceous Rudist-limestone beds, which to all appearances were completely fossilized and in most cases rolled before their incorporation. The latter include either quite fresh or but slightly rolled and broken early Tertiary forms, chiefly mollusca and corals.

[1] *Bulletin of the Museum of Comparative Zoology*, Harvard, vol. xxxiv, 1899. As regards Barbados, having examined both the Richmond Series in Jamaica and the Scotland beds in Barbados and their fossils, I am able to assert that there is no close resemblance between them. The Scotland beds consist of a thick series of sandstones, shales, and round-grained grits, frequently petroliferous. With the exception of some masses of a very hard sandstone whose exact original position is doubtful, all the fossils in the Scotland beds occur in a single thin conglomeratic band and seem to be referable to a considerably higher stage of the Eocene than either the Richmond beds or the Yellow Limestone of Jamaica. The molluscan fauna in the Scotland beds is quite different from any that I met with in Jamaica. Neither is there any trace in the Scotland beds of gneissose or metamorphosed rock fragments nor of any derived Cretaceous fossils, such as occur in the Richmond beds.

Mr. A. Menzies, the Geologist of the British Union Oil Company, has recently made a detailed survey of the Scotland district and other areas of Barbados and has succeeded in elucidating some very interesting structural features. I am much indebted to him for pointing out to me the fossils at several localities in the area occupied by the Scotland series.

These polygenetic conglomerates comprise also the sweepings of some now denuded or submerged land which was composed of gneissic and schistose rocks together with quartzite, clay slate, veined jasper-like rocks, chert, marble, and various igneous rocks. Silicified wood in more or less rolled masses also occasionally occurs.

It is clear to anyone who examines the conglomerates of this formation with their numerous rolled pebbles and fragments of limestone and other rocks (some of which are semi-metamorphosed, while others contain well-preserved Cretaceous fossils) that the Cretaceous beds of the area had already been brought more or less into the condition of fossilization and metamorphism in which they now are before they were subjected to the denudation and erosion which produced the Richmond beds. The conglomerates of this series of Jamaica bear a rather similar relation to the Cretaceous Limestones as the Permian Brockrams of the north of England do to the Carboniferous Limestones. Rolled masses of limestone, together with chips and fragments of the larger Rudistæ and complete more or less rolled examples of *Radiolites*, *Actæonella*, *Pterocera*, corals, etc., occur, all of which seem as completely fossilized as the Carboniferous fossils in the Brockram are.

Tertiary fossils occur sparingly in some of the shales and gritty sandstones, but at Port Maria they are common among the coarse conglomerates near the base of the section. Most of them are broken and slightly rolled, and were evidently derived from some little distance away. The presence of several shells of fluviatile and freshwater mollusca among the fauna at Port Maria suggests the proximity of some river down which they may have been washed and mingled with marine forms on a pebbly shore line. Others, especially some fragile tubular structures (*Burtinella*) that occur in the higher sandy shales at Port Maria, certainly grew in the place where they are now seen. Bivalve shells, sometimes of small and fragile species, are found with both valves conjoined among the conglomerates, so that the assemblage both of fossils and rocks in the sea cliffs near Port Maria is a sufficiently varied and interesting one.

A certain comparison may be suggested between this formation of Jamaica and the Flysch of the European Alpine system. The shales and carbonaceous limestones of Jamaica, which are very sparsely fossiliferous except for the occurrence of obscure plant fragments, are rather suggestive of some beds of the Flysch, while the presence in the conglomerates of rock fragments strange to the area of Jamaica at the present day is suggestive of the Nagelflue conglomerate of Switzerland. The manner in which this formation partakes in the uplift and folding of the Blue Mountain system of Jamaica also recalls the behaviour of the Flysch in some regions.

It is clear that the conglomerates and other beds resulted from the denudation of some Antillean land uplifted and altered and

intruded in early Tertiary time and that they were further involved in the continued uplift and foldings of the Blue Mountain system.

Judging from the diminution of the number of fragments of limestone in the conglomerates in the west of Jamaica, one might conclude that the land mass lay to the north and north-east. It is possible also to surmise from the north-westerly to south-easterly trend of the outcrops of the Carbonaceous Shale Series in the Blue Mountain area that the pressure that folded this series of rocks may have been exerted from the north-east, but these assumptions are at present, to say the least of it, doubtful.

Stratigraphical Position.

The Carbonaceous Shale beds are locally developed in Jamaica, and in some sections are quite absent or may be represented only by a few feet of shale. For instance, along the stretch of railway line between Cambridge and Catadupa the Yellow Limestone follows upon the Rudist Limestone with apparent conformity with only about 20 feet of red or brown very sparsely fossiliferous shale intervening. A similar condition of affairs obtains above Logie Green on the Rio Minho, where the Yellow Limestone appears in a road cutting some 20 or 30 feet above the Rudist Limestone; the actual junction, however, was not visible.

J. G. Sawkins[1] remarks that these shales (which Mr. Barrett and others considered to be of Eocene age after examining the fossil corals they contained) are nearly related to the Cretaceous group, to which they are apparently in some instances conformable, as on the hills near Arthur's Seat, west of the Pindars River, where they form a dome-shaped arch resting on Hippurite Limestone.

The geological mappers in 1865, however, seem to have been to some extent puzzled by the formation, and in their section at the end of the report, though referring the series to the Eocene, they place it below the Trappean beds but above the Hippurite Limestone.

Sawkins (page 24) estimates the mean thickness of this series on the Rio Minho and Hollis Savannah as not less than 1,500–2,000 feet, but he apparently includes some of the Trappean beds in this estimate since his map in this district indicates only Trappean beds. It is evident on reading page 253 that the field evidence regarding the position of these beds in the Parish of Hanover is rather uncertain, as he there describes the Black Shales after the Trappean beds as though they lay underneath. In discussing the Trappean in the Parish of Westmoreland (p. 232), he remarks that it is extremely difficult to distinguish the boundary between the Black Shales and the Trappean Series, and he places them here between the Trappean and the Cretaceous Limestone and maps them as surrounding the latter. In the Great River valley, however, the Carbonaceous Shale Series seemed to me to be absent, the Yellow

[1] "Reports on the Geology of Jamaica": *Mem. Geol. Surv.*, London, 1869, p. 25.

Limestone following closely on the Rudist Limestone and Cretaceous Shales as it does in the railway cutting between Cambridge and Catadupa which runs along the north slope of the same valley.

However, in Sawkins's description of the Parishes of St. George and Metcalfe (p. 121), and in that of St. Mary, the Black Shales are discussed at length and are referred to a position just below the White Limestone. In the former district the Yellow Limestone and Trappean Series are reported to be missing, and the Black Shale Series with its conglomerates and other beds is said to be 1,400 feet thick. Sawkins, in a north to south section across the Yallahs River to the south-east of Kingston, indicates the Black Shale as resting unconformably on the "metamorphosed" beds.

R. T. Hill (p. 53), who adopted the name of Richmond Formation apparently for the whole of the Carbonaceous or Black Shale beds of Sawkins and Brown, refers them to the upper division of his Blue Mountain Series. There are numerous Richmonds in Jamaica, but Hill's term is apparently derived from a place of that name in Metcalfe Parish about 9 miles south of Port Maria, but the place, by the way, stands on an area coloured yellow in Hill's map as indicating conglomerates and tuffs of Cretaceous age. Hill, in his geological section and in his text (p. 43), places the Richmond Series below his Catadupa and Cambridge beds, which, as I have already shown in a paper in this magazine,[1] comprise a mixed sequence of both Eocene and Cretaceous limestones.

I find it somewhat difficult clearly to understand the relationship of the Yellow Limestone to the Carbonaceous Shale Series. The latter does not follow persistently below the White Limestone as the Yellow Limestone does, and is entirely wanting in some localities, and present in other districts where the Yellow Limestone also appears fully developed. Where the Carbonaceous Shale is missing it is possible that it is represented by a portion of the Yellow Limestone.

As has already been mentioned, the Carbonaceous Shale and its accompanying conglomerates in the eastern part of Jamaica have shared in the deformation and uplift of the Blue Mountain system, and are there referable structurally and tectonically to the Blue Mountain Series rather than to the Yellow Limestone.

From what I saw of Jamaican geology I have no doubt that this series occupies a position above the Cretaceous Shales and Rudist Limestones, and that it is in the main earlier than the Yellow, and, of course, earlier than the White Limestones. The Carbonaceous Shale Series with its massive conglomerates near the base may perhaps be regarded as the initial stage in a cycle of deposition which passed on to the shallow water conditions of the Yellow Limestone, and culminated in the more widespread and deeper water formation of the White Limestone.

[1] "The Cretaceous and Tertiary question in Jamaica": GEOL. MAG., Vol. LIX, 1922, p. 426.

Distribution and Description of Sections Observed.

The general distribution of the various beds of the Carbonaceous Shale Series is well shown, though not everywhere so satisfactorily as one might desire, on the survey map of Sawkins and Brown. Unfortunately, however, on this map the grey colour which marks this formation is almost exactly the same as that applied to the White Marls of late Tertiary age which overlie the White Limestone, and which are widely spread in certain parts of the island. This similarity of colouring on Sawkins' map seems to have led R. T. Hill astray in his map of Jamaica. He there indicates large areas along the north coast between Dry Harbour and St. Ann's Bay, and also north of the entrance of Bog Walk Cañon in the east central part of the island as Richmond Beds, whereas the rock is in reality only White Marl. The extent of the three chief exposures of the Carbonaceous Shale may now be briefly indicated, starting in the extreme east of Jamaica and proceeding westward.

a. Exposures near Port Antonio in Portland Parish extending to the south and south-east.

In the north-east and east of the island an outcrop covering a relatively small area stretches as a band along the right bank of the Rio Grande from near Providence about 3 miles south of Port Antonio southwards and south-eastwards to a place called Mooretown, where it adjoins a mass of Rudist Limestone and Trappean and "metamorphosed" beds.

South of Providence in a roadside section the Carbonaceous Shale seemed to me to follow with conformable dip upon a Cretaceous Rudist Limestone which here overlies the fossiliferous Trappean Series.[1]

A good section is observable on the right bank of the Rio Grande near the point where the Back River joins it. The Carbonaceous Shale here contains a bed about 20 feet thick of coarse conglomerate enclosing rounded masses of whitish yellow limestone with plates and spines of echinoderms and other fossils, such as rolled *Radiolites*, rolled fragments of *Caprina* and "*Caprinula*" *gigantea*, masses of chert and various igneous rocks. No Tertiary fossils were seen. The conglomerate beds are quite lenticular and discontinuous, and occur interbedded in a thick grey felspathic sandstone.

At and around Mooretown about 4 miles south-east of the exposure just described, there is a regularly bedded band of material 5 or 6 feet thick among the shales, which from a short distance away appears to be a limestone full of fossil shells. On a close inspection, however, it is seen to consist of a mass of small chips and fragments of white and grey limestone in which bits of *Caprina* and other Rudistæ are recognizable. The whole mass would seem to have

[1] The Trappean Shales at Providence contain a fairly rich marine fauna apparently of Campanian age, which seems to be the oldest represented in Jamaica.

been washed down and deposited as a paste or sludge among the very regularly bedded shales above and below it. These friable dark shales seemed to be quite devoid of fossils.

b. Exposures near Port Maria, extending to the south-east.

Further to the west the series is exposed in the coast sections from Annotta Bay and the mouth of the Agua Alta or Wag Water north-westwards to Port Maria. The outcrop is continued inland in a broad band in a south-easterly direction practically across the island passing to the west of Blue Mountain Peak, the highest point 7,300 feet high, to the head waters of the Rio Negro and Morant Rivers. This is the most extended area of these beds in Jamaica, but it must be understood that the boundary of these beds and the Trappean or Metamorphosed Series is by no means well defined.

Impure limestones of a dark and compact nature and generally very regularly bedded form a considerable thickness of the Carbonaceous Shale Series in this outcrop, especially in the valley of the Buff Bay River above Balcarries and in the neighbouring valleys to the east. Sawkins maps an elongated outcrop of limestone as Cretaceous Limestone in these valleys, but does not extend it on his map to the Buff Bay River valley where, in fact, it appeared to me to be thickly developed. It seemed here to be quite unfossiliferous and quite unlike the Cretaceous Limestones of the island. Elsewhere, however, a limestone similar in position and appearance yields fossils. This is the case with a series of grey nodular limestone bands some 30 feet thick, which occur among conglomerates and sandstones at an altitude of about 3,000 feet above sea-level and about 1,000 feet below Newcastle Barracks on the southern Blue Mountain slopes.

Similar beds are seen again on the northern side of the Blue Mountain divide below Hardware Gap at a still higher altitude. These limestones yielded no other fossil except a species of *Ostrea*, but so broken up and poorly preserved as to be specifically indeterminable.

The stratigraphy of the Blue Mountain area, however, is too involved for me to be able to say for certain whether all these oyster-bearing beds of limestone should be referred to the Carbonaceous Shale Series or not.

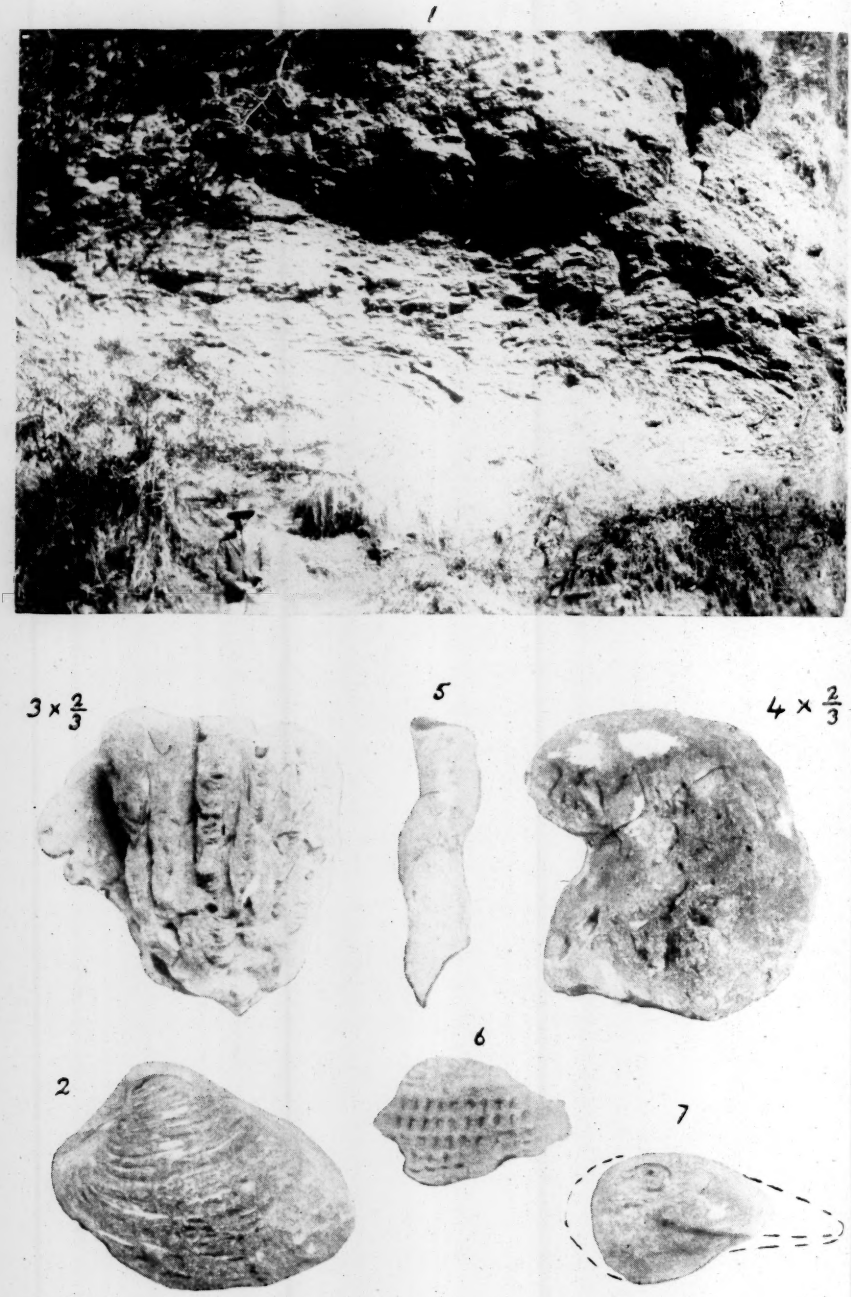
In the south-east of Jamaica, about 7 miles east of Kingston, near Newstead, on the west branch of the Chalky River, beds apparently belonging to this series are seen adjoining a Yellow Limestone which here forms the base of the White Limestone. They dip very steeply and consist of carbonaceous shales and felspathic sandstones and conglomerates made up of limestone, granite, andesite, and other fragments. These include a very large block of grey limestone some 20 feet in diameter. These beds, however, are situated on an area which Sawkins maps as metamorphosed series.

The most interesting exposure, however, and the only one where Eocene fossils are at all common, is that on the sea coast east and west of Port Maria. The higher beds at Port Maria occur only a short distance away from the overlying White Limestone, but I could not observe the nature of the junction. Sawkins records the occurrence of a rolled *Barrettia* among the derived material in the conglomerates in this district.

The section exposed in the cliffs at Fort Baldano or Point Haldane to the north-west of Port Maria appeared to me as follows, though neither the top nor the base of the series is actually visible.

	Approximate thickness in feet.
Friable pebbly decomposed felspathic sandstone with shell fragments, *Vermetus*-like tubular structures, etc.	10
Well bedded grey shales	5
Friable pebbly ferruginous sandstone with shell meal	7
Massive grey pebbly sandstone with rounded pieces of extraneous limestone	10
Gritty bed with rolled pieces of *Carolia* and *Ostrea* and rolled specimens of *Cerithium*, *Ampullina*, *Turritella*	5
Grey fine-grained sandstone with nodular concretions and sandy galls	5
Pebbly sandstone with a few fossil oysters	3
Grey well-bedded shales	6
Sandstone with occasional rolled *Ostrea*	10
Conglomerate full of rolled pieces of Cretaceous limestone	20
Grey and green sandstones	5
Conglomerate with Cretaceous limestone and rolled Rudistæ, an occasional rolled *Actaconella* or *Pterocera*, fragments of igneous rock, occasional pieces of gneiss and schistose rocks, pebbles of agate, quartzite, veined clay slate, vein stuff, black shale, limestone and marble; very large angular fragments of a decomposed andesitic lava. Numerous Tertiary shells fresh or slightly rolled, *Cerithium*, *Ampullina*, and *Ostrea* predominating. One broken specimen of *Velates* sp. Fragments of corals	30
Coarse grey sandstone	10
Coarse conglomerate similar to that above but with fewer Tertiary fossils	40
Sandstones	?

About 8 miles south-south-east of Port Maria there are some good exposures in road cuttings where conglomerates occur among the grey shales. The stones include many large and small rounded fragments of limestone, some dark-coloured, others light and semi-marmorized, rolled Rudistæ and fragments of "*Caprinula*" *gigantea*, while large masses of limestone full of *Caprina* occur. Pieces of metamorphic rock and masses of andesite-like lava are also seen, but Tertiary fossils seemed very scarce. These are, however, most easily found on the seashore where the conglomerate has been subjected to washing action, the Eocene fossils occurring in the finer material between the larger rolled fragments.



C. T. T. photo.

SECTION SHOWING OVERFOLDED CARBONACEOUS SHALES.
CRETACEOUS AND TERTIARY FOSSILS FROM THE CARBONACEOUS SHALES.

To face p. 9.]

c. Exposures in and around Lucea Harbour in Hanover Parish.

The exposures hitherto described are associated with the Blue Mountain district. Another important outcrop of the Carbonaceous Shales or Richmond beds occurs in the far west of Jamaica, and is excellently seen along the coast for several miles east and west of Lucea Harbour. A large expanse of it occurs inland to the south and south-west in continuation of the coast exposure. At several points in this area folds and overthrust folds are to be seen in the thin bedded shales (Pl. I, Fig. 1) and generally the formation is here considerably disturbed and dips at high angles.

The intense folding and disturbance of the thinner and softer beds in this part of Jamaica may be a feature resulting from faulting of the more massive beds, but I think the tectonic significance can only be elucidated after a more complete survey of the island on a larger scale has been made. It is not yet realized to what an extent faulting has modified the general anticlinorium of which the island consists.

On the road side about 2 miles south of Lucea a hard welded dark-coloured conglomerate about 50 feet thick occurs in massive beds dipping to the north-east and is quarried for road metal. It consists of large and small masses of various igneous and metamorphic rocks. Limestone pebbles are scarce, but I found some of dark limestone with remains of "*Caprinula*". Tertiary fossils comprised but one doubtful example. Further to the south-west these beds are succeeded by a series of very thinly and regularly bedded nodular Carbonaceous Shales which are very unfossiliferous. These must be several hundred feet thick and are locally remarkably disturbed and thrown into overthrust folds. In the upper beds near Glasgow, some 6 miles south-west of Lucea, and a short distance under the Yellow Limestone (which is typically developed in this area), beds of well-rounded igneous and other pebbles occur.

Palæontology.

The fossils I collected in the Carbonaceous Shale of Jamaica are as follows :—

(*a*) *Cretaceous derived fossils.*

Radiolites sp. A fossilized and slightly rolled example with the upper valve in place partly crushed into the living chamber. It appears to be identical with, or nearly allied to, *R. cancellatus* Whitfield. (Illustrated Pl. I, Fig. 3.)

Radiolites sp., possibly *R. rudis* Whitf. Several examples in the form of very much rolled pebbles.

Caprinella cf. *occidentalis* Whitf. A much rolled upper valve. (Pl. I, Fig. 4.)

Caprinula gigantea Whitf. Much rolled fragments showing the characteristic tubular structure.

Actaonella sp.

Pterocera sp. Much rolled examples.

Coral fragments, including Cretaceous with possibly some Tertiary forms. The two series are not easy to distinguish.

All the above, together with other derived fragments, are such as might occur in the Rudist Limestones at present exposed at various localities in Jamaica.

(*b*) *Tertiary fossils.*

Velates sp. Cf. *V. noetlingi* Cossm. and Piss. of the Upper Ranikot beds.
Ampullina sp. Cf. *A.* (*Crommium*) *insolita* Desh. of the Cuisian.
Ampullina (*Crommium*) sp. Cf. *A.* (*Crommium*) *lignitarum* Desh. of the Sparnacian.
Natica mariensis sp. nov.
Natica sp. Cf. *Ampullina paytensis* Woods of the Lobitos formation of Peru.
Natica (*Naticina ?*) sp. Cf. *N. ampulliniformis* Coss. and Piss. of the Ranikot beds.
Siphonalia sp. Cf. *S. mariæ* Melleville and *S. planicostata* Melleville of the Thanetian.
Morgania mariensis sp. nov. Cf. *M. magna* Woods from Parinas sandstone of Peru.
Bezanconia woodsi sp. nov. Cf. *B. pupoidea* Woods from Peru.
Pyrazus matleyi sp. nov. Cf. *P. pyramidatus* Desh. of the Cuisian.
Tympanotonus sp. Cf. *T. funatus* Mantell from the Sparnacian.
Terebralia sp. Cf. *Terebralia* sp. from the Eocene of Nigeria.
Faunus (*Melanatria*) *vulcaniformis* sp. nov. Cf. *F. vulcanicus* Schl. of the Cuisian.
Potamides (?) sp.
Potamides cf. *carbonicola* Cooper. Cf. *P. carbonicola* from the Tejon beds.
Potamides sp. Cf. *P. cinctus* of the Cuisian.
Melanopsis sp. Cf. *M. sodalis* Desh. of the Thanetian.
Bayania (?) sp.
Turritella sp. Cf. *T. adulterata* of the Lutetian.
Vermetus (*Burtinella*) sp. Cf. *V.* (*Burtinella*) *semipedalis* Desh.
Ostrea sp. Cf. *O. Angusta* of the Cuisian.
Carolia (?) sp.
Corbis sp. Cf. *C. major* Bayan of the Monte Postale beds.
Cyrena or *Corbicula.*
Raeta or *Raetomya* sp. Cf. *Raeta schweinfurthi* Mayer-Eymar of the Mokattam beds.

The Tertiary fossils enumerated above do not afford any very definite evidence as to their horizon, a difficulty which is further increased by the fact that many of them are freshwater or estuarine forms, and most of the specimens are broken at the spire and lips. It will be seen that the majority of them appear to have affinity with forms in the Cuisian, Sparnacian, or Thanetian, or with the Ranikot beds. This fact, when taken together with the inferior position of the Carbonaceous Shale Series, refers them to an earlier period than the Yellow Limestone of Jamaica, whose fauna is Lutetian or Middle Eocene. I cannot trace any certain evidence of a Carbonaceous Shale species passing up into the Yellow Limestone, and the Yellow Limestone contains no derived Cretaceous fossils. With the exception of the *Raeta* or *Raetomya* from Providence, near Port Antonio, all the Tertiary fossils herein described are from the conglomerates and shales at Port Maria.

Notes on the Tertiary Mollusca.

Velates sp. (Pl. I, Fig. 7.)

A single fragment of a *Velates* broken before its incorporation in the rock occurred in the conglomerate at Port Maria. It com-

prises the spire, a portion of the outer lip, part of the rounded base, and part of the inner lip with some of the teeth on it. The spire forms a small elevated knob, and is made up of two or three flattened whorls, the basal callosity is large and rounded, and encroaches on the dorsal surface reaching nearly to the spire, the outer lip is thin. About two-thirds of the inner lip are preserved and bear four blunt teeth.

A certain specific determination of this rather meagre fragment is not possible. It has a very faint columellar depression in front of the spire, which is much more nearly marginal than it is in typical examples of *V. schmideliana* of this size, and the basal callus is much larger and more rounded. As regards the swollen basal callosity and other features, it seems to come nearest to *V. noetlingi* Cossm. and Pissarro,[1] which is said to be abundant in the three upper zones of the Upper Ranikot Series.

Ampullina sp. (Pl. II, Fig. 17.)

Description.—Shell of five whorls, thick, almost sphæroidal, whorls rounded, spire low and blunt, suture deep, mouth oval. There is no umbilicus, and the inner lip has a rather thick, smooth spreading callosity; the outer lip is missing. Growth lines are fairly well impressed.

Dimensions.—Height 23 mm., diameter 23 mm.

Locality.—Conglomerate at Port Maria. Three specimens.

Remarks.—The callosity of the inner lip resembles that on *Ampullina* (*Crommium*) *insolita* Desh. from the Cuisian of Cuise as illustrated in *Iconographie*, tome ii, pl. xi, figs. 64–16.

Ampullina (*Crommium*) sp. (Pl. II, Fig. 18.)

Description.—Shell of five whorls, thick, large, sub-globular, spire rather elevated, sutures deep, whorls smooth, rounded, inner lip with a smooth and spreading callosity. There was apparently none or only a faint umbilicus, and the outer lip and anterior portions of the shell are missing.

Dimensions.—Height about 40 mm., diameter about 36 mm.

Locality.—Conglomerate at Port Maria. Fairly common.

Remarks.—This shell seems to agree in height of spire and general shape with *Ampullina* (*Crommium*) *lignitarum* Desh. of the Sparnacian of Pourcy (*Iconographie*, tome ii, pl. xi, figs. 64–21), but the Jamaican form seems to have deeper and more excavated sutures.

Natica mariensis sp. nov. (Pl. II, Fig. 15.)

Description.—Shell of five whorls, very thick, outline oval, spire elevated, sutures shallow, whorls gently rounded, mouth oval pointed posteriorly, no umbilicus, the callosity of the inner lip apparently very slight. The growth lines are scarcely apparent.

[1] "Mollusca of the Ranikot Series": *Pal. Ind.*, N.S., vol. iii, Mem. I, 1909, p. 76, pl. vi, figs. 24–7.

Dimensions.—Height 29 mm., diameter of body whorl 22 mm.
Locality.—Conglomerate at Port Maria, one specimen.

Natica sp. (Pl. II, Figs. 19 and 20.)

Description.—Shell of five whorls, very thick, sutures rather deep, spire rather elevated but blunt, less than half the height of the body whorl, which is swollen beneath the suture, but narrows anteriorly. The mouth is oval and the inner lip has a callosity which partly conceals a slight narrow umbilicus, the outer lip is broken away. Shell surface rounded, with faint close-set growth lines.

Dimensions.—Height 22 mm., diameter of body whorl 18 mm.
Locality.—Conglomerate at Port Maria. Fairly plentiful.
Remarks.—This shell seems rather to resemble in shape *Ampullina paytensis* Woods[1] recently described from the Lobitos formation of Peru.

Natica (*Naticina?*) sp. (Pl. II, Fig. 16.)

Description.—Shell of five whorls, very thick, sub-globular, sutures linear but well marked. The spire is eroded, but has been rather elevated. Shell surface gently rounded, with fairly well-marked growth lines. The mouth and umbilical region are hidden in the rock.

Dimensions.—Height 29 mm., diameter 25 mm.
Locality.—Conglomerate at Port Maria. One specimen.
Remarks.—In general shape it seems to have some resemblance to *Natica* (*Naticina*) *ampulliniformis* Cossm. and Piss.[2] from the lowest beds of the Upper Ranikot Series, but it is rather larger. It also rather resembles a specimen of *Lunatia hornii* Gabb. of the Tejon and Martinez Formations as illustrated by R. E. Dickerson.[3]

Siphonalia sp. (Pl. II, Fig. 14.)

Description.—Shell moderately thick consisting of six whorls, suture rather shallow, spire less than half the height of the body whorl, siphon rather long and moderately bent, surface decorated with rather irregularly spaced elongated nodes, of which there are about thirteen on the body whorl. The surface otherwise seems to have been smooth except for a series of rounded spiral ridges which develop on the anterior part of the body whorl towards the channel. The decoration is, however, partly obliterated by erosion or rolling.

Dimensions.—Length 47 mm., diameter of body whorl 26 mm.
Locality.—Conglomerate at Port Maria. One specimen.
Remarks.—This shell rather resembles *S. mariæ* Melleville and

[1] T. O. Bosworth, *Geol. of Tertiary and Quaternary of N.W. part of Peru*, 1922. Palæontology by H. Woods and others, p. 77, pl. vii, figs. 3, 4.
[2] *Pal. Ind.*, N.S., vol. iii, No. 1, 1909, p. 67, pl. vii, figs. 6–8.
[3] "Fauna of the Martinez Eocene of California": *Bull. Univ. Calif. Publ.*, vol. viii, No. 6, May, 1914, pl. xiii, fig. 5.

S. planicostata Melleville, both from the Thanetian of Chenay (*Iconographie*, tome ii, pl. xxxviii, figs. 186—1 and 2); especially the former, but the siphon in the Jamaican shell is longer and less twisted.

Morgania mariensis sp. nov. (Pl. II, Fig. 3.)

Description.—Shell originally of nine or ten whorls, of which only the last four remain, sub-fusiform in shape, narrowing anteriorly. The whorls are smooth and slightly convex, marked by two incised spiral grooves, one rather deeply and regularly incised occurs slightly above the middle of the earlier whorls and about a quarter the distance below the suture on the body whorl. The other groove is fainter and corresponds with the suture on the earlier whorls, but on the penultimate whorl it appears just above the suture. The suture is shallow and linear, the inner lip has a small rounded callosity, the outer lip and spire are missing.

Dimensions.—Length originally about 70 mm., diameter of penultimate and body whorls 21 mm.

Locality.—Conglomerate at Port Maria. One specimen.

Remarks.—The absence of spire and outer lip makes the generic attribution rather uncertain, but I have little doubt that it is referable to the above genus which is not distantly related to the living genus *Faunus*. The type species of the genus *Morgania* (*Vicarya*) *fusiformis*[1] Hislop from the Cretaceous or Eocene of Nagpur India is a much smaller shell. The present form is about the same size as *Morgania magna* Woods,[2] recently described from the Parinas Sandstone near Negritos in Peru, but that has four incised lines near the anterior part of the body whorl. Another smaller species of the same genus, *M. costata* Woods, illustrated on the same plate, has a large number of spiral ribs and furrows on the later whorls.

Bezanconia woodsi sp. nov. (Pl. II, Fig. 2.)

Description.—Shell sub-fusiform or pupoidal, the last three whorls only preserved, whorls smooth, surface very slightly rounded, suture shallow but well marked, the margin of the whorls sharp and projecting slightly above the suture. The body whorl has a deep basal channel which is covered at the inner lip by a thin callosity. The anterior canal is well marked off by the basal excavation, it measures about half the length of the body whorl, is expanded anteriorly and decorated with five spiral rounded ribs. The outer lip and spire are broken away.

Dimensions.—Original length about 65 mm., diameter of body whorl 20 mm.

Locality.—Conglomerate at Port Maria. One specimen.

Remarks.—This form differs from the typical *B. spirata* Lam.

[1] Cossmann, *Essais de Palæoconchologie Comparée*, viii, 1909, p. 164, pl. iii, figs. 14, 15.

[2] *Geol. of Tert. and Quat. in N.W. Peru*, 1922, p. 82, pl. ix, figs. 5, 6.

of the Calcaire Grossier in its smaller size and the much less deeply channelled sutures, and in the shorter and more compressed anterior channel, which, however, in the Paris Basin shell is marked with similar spiral ribs. The aperture also is not completely detached from the last whorl as it is in *B. spirata*. A species, *B. pupoidea*[1] Woods, has recently been described from the Turritella beds near Negritos in Peru. In the Peruvian shell the suture is less impressed, the basal channel shallower, and the anterior canal shorter. Mr. H. Woods gives an enumeration of the three or four known species of this genus. Perhaps the most striking of these is *B. cossmanni* Oppenheim from the Monte Postale beds of Middle Eocene age.

Pyrazus matleyi sp. nov. (Pl. II, Fig. 4.)

Description.—Shell of about eleven whorls, which increase gradually, suture shallow, surface decorated with a series of vertical ridges, seven or eight on a whorl, which occur more or less regularly in a line below one another, but on some examples those on the later whorls are placed rather behind the corresponding ridges on the preceding whorl. The ridges die away on the anterior part of the body whorl, which becomes rather inflated, and tend to be eroded on the early whorls. The grooves between the ridges are decorated with about eleven spiral ridges, which pass across the vertical ribs, but in the hollows between are cut up into a series of fine granular nodes. The spiral ridges become broad and coarse on the anterior part of the body whorl. The lip is not preserved, but there is a thin columellar callus.

Dimensions.—Height about 105 mm., diameter of body whorl 36 mm.

Locality.—Conglomerate at Port Maria. Five specimens.

Remarks.—The earlier whorls resemble *Pyrazus pyramidatus* Desh. from the Cuisian of Cuise as it is figured by Cossmann and Pissarro (*Iconographie*, tome ii, pl. xxix, 151 ter. 2), but in the Paris Basin example the body whorl is missing and the vertical ribs are placed more definitely in a straight line. The Jamaican form seems to be an altogether larger shell. I take the opportunity to name it after Dr. C. A. Matley at present the Government geologist in Jamaica.

Tympanotonus sp. (Pl. II, Fig. 6.)

Description.—Shell of about eleven whorls which increase rather rapidly, suture shallow but the later whorls are platformed below it. The earlier whorls are decorated with four or five equal spiral lines more or less cut up into nodes. About the seventh whorl a line of nodes which increase in size develops below the suture and becomes very prominent on the last whorl. Below these on the body whorl there are ten spiral ridges of variable width, three or

[1] T. O. Bosworth, D.Sc., H. Woods, F.R.S., and others, *Geol. of Tertiary and Quaternary periods in N.W. Peru*, 1922, p. 89, pl. xi, figs. 6–8.

four of which are cut up into nodes. The inner lip has a rather massive reflected callosity, but the outer lip is broken away.

Dimensions.—Original length about 70 mm., diameter of body whorl 28 mm.

Locality.—Conglomerate at Port Maria. Five examples.

Remarks.—The only Paris Basin shell which seems at all to resemble this is *T. funatus* Mantell from the Sparnacian of Rilly and Pourcy, but the Jamaican form is larger with bolder ornamentation.

Terebralia sp. (Pl. II, Fig. 5.)

Description.—Fragments consist of three or four flat-sided whorls, increasing gradually. The suture is well marked and forms a rather wide and deep groove with rounded bottom. Whorls are decorated with about eighteen prominent slightly inclined rounded longitudinal ribs, which are crossed by six or seven rounded spiral ridges. The inner lip has a flattened callosity, the outer lip being broken away.

Dimensions.—Original length about 70 mm., diameter of last whorl 25 mm.

Locality.—Conglomerate at Port Maria. Five examples.

Remarks.—This shell rather resembles a figure of *Terebralia* sp. from the Eocene of Nigeria.[1]

Faunus (*Melanatria*) *vulcaniformis* sp. nov. (Pl. II, Fig. 1.)

Description.—Shell of about ten whorls increasing gradually, the decoration on the first three obliterated by erosion. The later whorls are decorated each with about fifteen slightly inclined longitudinal ribs, which are produced into rather acute spines above the suture and disappear about the anterior half of the body whorl. The surface of the whorls is decorated with rounded spiral equidistant ridges, of which there are about twelve on the body whorl. The last two whorls are rather inflated and the suture somewhat deeply impressed. The inner lip does not seem to bear a callus and the outer lip is broken away.

Dimensions.—Length about 73 mm., diameter of body whorl 28 mm.

Locality.—Conglomerate at Port Maria. Fairly common.

Remarks.—This seems without doubt to be a freshwater shell. It rather resembles *Faunus* (*Melanatria*) *vulcanicus* Schl. from the Cuisian, but in the Jamaican shell the whorls increase less rapidly, the vertical ribs are more numerous, and the suture is deeper.

Potamides (?) sp. (Pl. II, Fig. 7.)

A fragment of a shell consists of three flattish whorls which increase gradually in size, the suture is shallow, below the suture there is a line of nodes, and below this about five spiral lines of irregular size which tend to become lines of nodes, the line just above the suture being larger than the others. The shell has been about 55 mm. long, and occurred in the conglomerate at Port Maria.

[1] R. B. Newton, "Eocene Mollusca of Nigeria": *Geol. Surv. Nigeria*, Bull. 3, 1922, p. 46, pl. iv, figs. 10, 11.

Potamides cf. *carbonicola* Cooper. (Pl. II, Figs. 8 and 9.)

Description.—Shell sub-columnar, whorls about twelve increasing very slowly in size, sides flat. The suture is well impressed, forming a shallow round bottomed channel, the whorls are decorated with three concentric spiral lines of blunt nodes, which are joined together by faint vertical ridges and form a somewhat reticulate ornamentation. The inner lip has a thin callosity, the outer lip is broken away.

Dimensions.—Length about 45 mm., diameter of body whorl 14 mm.

Locality.—Conglomerate at Port Maria; rather plentiful.

Remarks.—These specimens are rather variable. The original figures of *P. carbonicola*[1] are not very clear; the Jamaican examples are more like some figured by R. Arnold[2] from the Tejon of California, except that the nodes do not resolve themselves into spiral ridges on the later whorls as they do on some of the Tejon examples.

Potamides sp. (Pl. II, Fig. 10.)

Description.—Shell of about twelve whorls increasing gradually, the sides slightly concave, sutures shallow. The decoration on the earlier whorls is eroded, on the later whorls below the suture there is a rounded raised ridge decorated with rather sharp nodes, and below this three rows of rather sharp nodes of which the middle line is the smallest. On some examples the decoration is somewhat variable and the line of nodes smaller and sharper than on others. Lip broken away.

Dimensions.—Original length about 35 mm., diameter of late whorls 12 mm.

Locality.—Conglomerate at Port Maria. Six examples.

Remarks.—In ornamentation and rate of increase of the whorls this shell resembles *P. cinctus* Brug, from the Lutetian and Bartonian, and *P. cinctus* var. *præcinctus* Cossmann from Cuise. (*Iconographie*, tome ii, pl. xxviii, figs. 151, 14.)

Melanopsis sp. (Pl. II, Fig. 11.)

Two specimens of *Melanopsis* from the conglomerate at Port Maria, more or less broken at the anterior end, bear resemblance to *M. ancillaroides* Desh. of the Cuisian and Sparnacian, or possibly more to *M. sodalis* Desh. of the Thanetian of Châlons-sur-Vesle in the Paris Basin. The more perfect specimen has been 22 mm. in length and 10 mm. in breadth.

Bayania (?) sp. (Pl. II, Fig. 12.)

A single specimen from the Port Maria conglomerate with the anterior portion missing seems to belong to this genus. The shell

[1] J. G. Cooper, "Cat. of Californian Fossils": *Bull. Calif. State Min. Bureau*, No. 4, 1894, p. 44, pl. i, figs. 14–19.

[2] "Palæontology of the Coalinga District": *U.S. Geol. Surv.*, Bull. 396, 1909, pl. iv, figs. 2, 3.

is thick and smooth, with traces of spiral grooves on the earlier whorls, the suture shallow but rather marked. It has been about 19 mm. long and 10 mm. broad, and is much shorter in the spire than the well-known Calcaire Grossier shell *B. lactea* Lam.

Turritella spp. (Pl. II, Fig. 13.)

Several broken and rolled *Turritellae* occur at Port Maria. On one of them there are two strong ridges above the shallow suture enclosing between them a shallow groove ornamented with one or more very fine spiral thread lines. Above these ridges the surface bears 8 or 9 fine irregularly spaced spiral thread lines with numerous much finer lines between them which are seen only with a lens. The shape and ornamentation recalls that of *T. adulterata* Desh. of the Lutetian of Chaumont.

Vermetus (*Burtinella*) sp. (Pl. I, Fig. 5.)

Description.—Shell tubular, circular in section, increasing slowly in size, growing straight for some distance, then curving and becoming fairly straight again. Surface smooth with very faint traces of growth lines.

Dimensions.—Length 40 mm., diameter 8 mm., but both ends are missing.

Locality.—Port Maria, in the friable sandstone beds high up in the section, apparently growing " in situ ".

Remarks.—This shell, the section of which is built up of concentric layers, bears some resemblance to *Vermetus* (*Burtinella*) *semipedalis* Desh. from Auvers, as illustrated in *Iconographie* (tome ii, pl. xxii, figs. 131–8).

Ostrea spp. (Pl. II, Fig. 21.)

Fragments apparently of several forms of *Ostrea* are numerous in the conglomerate at Port Maria, but those I collected are mostly so broken and rolled as to be indeterminable specifically. The figured specimen is an attached valve with a pointed and twisted apex and a long triangular area with a median sunken portion, and may be a young specimen of a species allied to *O. cariosa* Desh. of the Lutetian or *O. angusta* Desh. of the Cuisian of the Paris Basin.

Carolia (*?*) sp.

Fragments of a bivalve of platy structure with divergent ribbing like that on the above genus occur in the higher shales at Port Maria, but there is not enough evidence to show whether or not they belong to the forms of *Carolia* that occur so plentifully in the overlying Yellow Limestone.

Corbis sp. (Pl. I, Fig. 6.)

Pieces of a large thick-valved *Corbis* of the group of *C. subpectunculus* occur in the Port Maria conglomerate, but are generally so

incorporated in the hard rock that only small fragments can be extracted. These are insufficient to establish the species, but there is no doubt about the genus. The decoration on the fragment illustrated rather resembles that of *C. major* Bayan of the Monte Postale beds.

Cyrena or *Corbicula* sp. (Pl. II, Fig. 22.)

A small bivalve with the two valves joined measuring 14 mm. long, 11 mm. high, and 6 mm. in diameter, found in the conglomerate at Port Maria, seems to belong to this genus. The shell is thick and apparently partly eroded, and growth ridges are seen towards the margin. The valves are rather flat, the beaks almost medially situated, not rolled, and not very close together. Behind and in front of the beaks there is a rather long areal groove with traces of an external ligament behind the beak.

Raeta or *Raetomya* sp. (Pl. I, Fig. 2.)

Description.—Shell thin, valves inflated, beaks prominent, situated about the anterior third of the shell, close together. The valves are rather deeply and widely excavated in front of and below the beaks, and there is an ill-defined sunken dorsal area. The surface is decorated with about 27 concentric rather irregular well-raised rounded plications with round-bottomed grooves between them which become weak on the dorsal area. The outline has been rather obscured and the inflation of the valves increased by crushing.

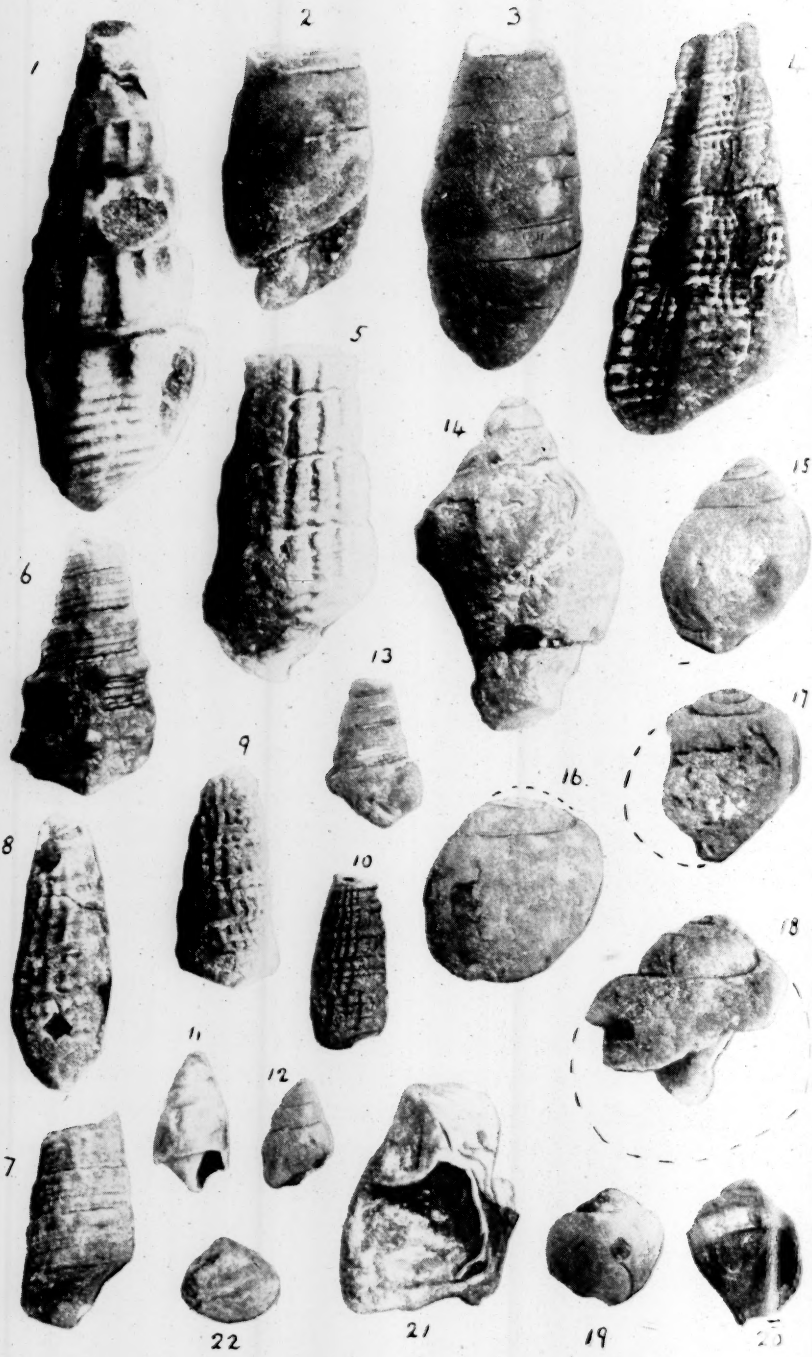
Dimensions.—Length 42 mm., height 31 mm., diameter of both valves 28 mm.

Locality.—Black Shales with *Turritella* sp. and *Cyclolites* sp. (possibly derived) in the bed of a stream (the West Town River on Sawkins's map) below and to the north-west of the farm called Providence, near Port Antonio. Sawkins marks the area as "Trappean", but the bed seemed to me to be Carbonaceous Shale. There is a possibility therefore that this shell may be a Cretaceous one, though the coral (*Cyclolites*) may have been derived from the Cretaceous shales near by, where specimens of it occur plentifully.

Remarks.—It bears a considerable resemblance to *Raëta Schweinfurthi* Mayer-Eymar [1] from the Upper Mokattam beds of Egypt. The generic attribution of this Jamaican shell, without a view of its hinge teeth, is uncertain since R. B. Newton has recently described specimens of the above-mentioned species from the Eocene of Nigeria as a new genus *Raetomya*.[2] The general shape of this and of the recent *R. canaliculata* Say, from Florida and South Carolina, is similar, but *Raetomya* has a differently constituted hinge apparatus.

[1] Oppenheim, *Alttertiarer Faunen in Aegypten Palæontogr.*, xxx, 1906, p. 190, pl. xix, figs. 1, 1*a*.

[2] *Geol. Surv. of Nigeria*, Bull. 3, 1922, p. 94, pl. 10.



C. T. T. photo.

EOCENE MOLLUSCA FROM THE PORT MARIA CONGLOMERATES.

To face p. 19.

EXPLANATION OF PLATES.

All fossils figured are in the Author's collection.

PLATE I.

FIG.

1.—Section of Carbonaceous Shale beds about 4 miles south-west of Lucea Harbour on the road to Glasgow, Western Jamaica, showing a series of folds in the thinner shales. The folds throw about south-west.

2.—*Raeta* or *Raetomya* sp. Natural size. Carbonaceous Shale (?). Providence near Port Antonia.

3.—*Radiolites* cf. *cancellatus* Whitfield. About two-thirds natural size. Conglomerate at Port Maria, derived from the Rudist Limestones.

4.—*Caprinella* cf. *occidentalis* Whitfield. About two-thirds natural size. Same locality. A much rolled upper valve derived from the Rudist Limestones.

5.—*Vermetus* (*Burtinella*) sp. Natural size. Sandstones at Port Maria high up in the section.

6.—*Corbis* sp. Natural size. Conglomerate at Port Maria. Fragment of the marginal portion of a valve.

7.—*Velates* sp. Natural size. Conglomerate at Port Maria. A broken example, the outline restored.

PLATE II.

All the specimens are from the Conglomerates at Port Maria and are represented approximately natural size.

FIG.

1.—*Faunus* (*Melanatria*) *vulcaniformis* sp. nov.
2.—*Bezanconia* woodsi sp. nov.
3.—*Morgania mariensis* sp. nov.
4.—*Pyrazus matleyi* sp. nov.
5.—*Terebralia* sp.
6.—*Tympanotonus* sp.
7.—*Potamides* (?) sp.
8.—*Potamides* cf. *carbonicola* Cooper.
9.—Ditto, another example.
10.—*Potamides* sp.
11.—*Melanopsis* sp.
12.—*Bayania* (?) sp.
13.—*Turritella* sp.
14.—*Siphonalia* sp.
15.—*Natica mariensis* sp. nov.
16.—*Natica* (*Naticina* ?) sp.
17.—*Ampullina* sp.
18.—*Ampullina* (*Crommium*) sp.
19.—*Natica*, sp.
20.—Ditto, another example.
21.—*Ostrea* sp.
22.—*Cyrena* or *Corbicula* sp.

The Geology and Petrography of Rockall.

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ALL students of the Thulean [1] (Brito-Arctic) province of igneous rocks will be interested to learn of the landing effected on the islet of Rockall in June, 1921, by Dr. Charcot, of Antarctic fame, at the instigation of Professor A. Lacroix, of Paris, who has recently described the new material thus obtained.[2] The writer believes that an account of the results so far achieved will be welcomed by British workers.

Before this expedition, only three small specimens of *rockallite*, the unique igneous rock composed of quartz, albite, and ægirine, in

[1] Term introduced by H. S. Washington, "Deccan Traps and other Plateau Basalts": *Bull. Geol. Soc. Amer.*, xxxiii, 1922, p. 780.

[2] "La Composition minéralogique de la rockallite": *Comptes Rendus*, Paris, t. 173, 1921, pp. 267–73. "La signification des granites alcalins très riches en soude": ibid. t. 177, 1923, pp. 417–22. "La constitution du banc de Rockall": ibid. pp. 437–40.

almost equal proportions, were known. These were obtained by British expeditions, the *Endymion* in 1810, and the *Porcupine* in 1862, and were described by the late Professor J. W. Judd, who first applied the name rockallite to the species.[1] The expedition undertaken under the auspices of the Royal Irish Academy in 1896, of which Judd's paper was the outcome, failed to land on the islet. In 1914 Dr. H. S. Washington re-described the rock and made a complete chemical analysis on half of one of Judd's specimens.[2] On this occasion the important discovery was made of rare earths, Ce_2O_3, etc., to the extent of ·37 per cent and zirconium oxide to the extent of 1·17 per cent in the rock.

The islet of Rockall, little more than a large stack, measures 20 metres in diameter by 21 metres in height. It rises from the Atlantic about 240 sea miles north-west of Ireland, about half-way between Ireland and Iceland. Landing on this almost sheer rock is extremely difficult because of the swell, which is incessant even in calm weather. Dr. Charcot gives a graphic account of the two landings, which were made on the 29th June and on the 1st July, 1921. "We made a circuit of Rockall (in a small boat) and assured ourselves that a landing was only possible on a little projection of the south-south-east angle, where the sea broke the least. Taking advantage of a favourable moment, Moussard jumped on to the seaweed-covered rock and gained a kind of fissure, where Le François joined him. The boat holding off a distance, a transfer rope was established, whereby hammers and chisels were passed, and by which the specimens were in turn brought aboard. It was extremely difficult and laborious to get specimens, because of the configuration and hardness of the rock and the insecure position of the two men. At 11.15 a.m. (after 1¼ hours on the rock) the two men, not without difficulty, jumped on board again." A second landing was made on July 1, when a projection on the vertical north-east face of the rock was gained a few metres distant from the first landing. A new series of specimens was thus obtained.

From the descriptions and photographs of the 1896 expedition Judd concluded that the lower part of Rockall was stratified, and surmised that it consisted either of tuffs or ordinary sediments, into which the rockallite, forming the upper part of the mass, was intruded as a sill. The Charcot landing, however, has shown conclusively that Rockall is igneous throughout. The apparent stratification towards the base is due to veins and schlieren, probably zones of differentiation, which have resisted the attacks of the waves better than the main rock, and stand out as parallel ridges. Furthermore, the unique type rockallite does not constitute the whole of the mass. It forms large and small fine-grained inclusions,

[1] "Notes on Rockall Island and Bank, with an Account of the Petrology": *Trans. Roy. Irish Acad.*, vol. xxxi, pt. iii, 1897, pp. 48–58.

[2] "The Composition of Rockallite": *Quart. Journ. Geol. Soc.*, vol. lxx, 1914, pp. 294–302.

analogous to the basic segregations found in ordinary granites, within a coarse-grained, leucocratic, ægirine-riebeckite-granite. The local concentrations of ægirine (and occasionally riebeckite), which produce rockallite, are of two kinds; one appears progressively without change of grain or texture, a kind of transition already known in other ægirine-granites, such as that of Corsica; the other is characterized by a rapid diminution in grain-size, the resulting rock of dark colour having the aspect of an inclusion. The albite crystals in this type tend to be slightly porphyritic, and stand out as white crystals on a greenish-black groundmass. It is this rock which was analysed by Judd and Washington, and which has served as the type of rockallite.

Washington discovered the abundance of zirconium and cerium in rockallite. The amount of zircon in the rock is far too small to account for the 1·17 per cent of ZrO_2 found. Hence Washington concluded that the cerium oxide (·37 per cent) and the greater part of the zirconia must be contained in the ægirine. In 1915 Professor A. Lacroix described the *fasibitikite* (ægirine-riebeckite-granite) of Madagascar,[1] which approaches rockallite in composition, and contains even larger amounts of zirconia and ceria. This, however, is easily explained in this case by the presence of a ceriferous eucolite, which was here found for the first time in a rock of the granite family.

By close examination of the Rockall specimens Lacroix found in all the material, but especially in the fine-grained rockallite, small clear specks, globular or hexagonal in shape, occasionally moulded on quartz or felspar crystals. This mineral reminded him at once of *elpidite* (silicozirconate of sodium), $H_6Na_2ZrSi_6O_{18}$, discovered some years ago in a pegmatite from a pyroxene-syenite at Narsarsuk, Greenland. Comparative microscopic study of the two minerals established their identity, or at least their close relationship. Spectroscopic examination showed in both minerals a complete spectrum of zirconium, accompanied in the Rockall mineral by that of yttrium. Thus cerium has not certainly been proved to occur in this particular mineral. It is, however, revealed by the chemical analysis of the rock. It might be contained in parisite (synchysite), a ceriferous mineral associated with elpidite and ægirine in Greenland, but microscopic examination has not disclosed the presence of this mineral. Lacroix finds it necessary to assume that the ceria is contained in a colloidal material which occurs here and there in small quantity along with the elpidite.

Hence the brown colour of some of the Rockall pyroxene is not due to the presence of rare earths, as supposed by Washington. In the fresh rocks it is always green; and the brown tinge begins to appear with alteration involving the formation of limonite.

Lacroix has had six new chemical analyses made (by M. Raoult) of the Rockall material, which are given below, along with the

[1] *Comptes Rendus*, Paris, t. 160, 1915, p. 253.

analysis of rockallite made for Judd by C. J. S. Makins, and the analysis due to Washington.

TABLE I: ROCKALL ANALYSES.

	1	2	3	4	5	6	7	8
SiO_2	70·48	68·61	59·18	63·26	67·38	68·04	69·80	73·60
Al_2O_3	8·84	9·24	9·21	5·24	4·71	5·78	5·10	4·70
Fe_2O_3	5·91	6·91	8·86	14·68	14·39	13·19	13·23	13·10
FeO	2·53	3·42	5·95	4·81	1·51	1·02	·78	n.d.
MgO	·39	·18	·76	·07	·08	·11	·11	·11
CaO	·46	·22	2·22	·90	1·38	·56	·72	·37
Na_2O	4·29	5·62	7·33	6·17	6·06	7·56	8·04	6·96
K_2O	4·75	4·29	3·97	2·62	2·30	·84	·22	tr.
H_2O+	·82	·24	·71	·53	·33	·89	·46	n.d.
H_2O-	·11	·34	·20	·25	·20	·20	·31	
TiO_2	·27	·41	1·17	·81	·70	·82	·34	—
P_2O_5	·05	·04	·31	·17	·05	·12	·07	—
MnO	—	·11	—	·17	·18	·07	·12	·93
ZrO_2	·82	·56	—	·46	·86	·66	1·17	—
Ceria and Yttria	·27	·16	—	·12	·16	·38	·37	—
NiO	—	—	—	—	—	·05	n.d.	·06
	99·99	100·35	99·87	100·26	100·29	100·29	100·84	99·83

1. Ægirine-granite, white vein, Rockall. II. (3) 4. 1. 3". Varingose-grorudose.
2. Ægirine-granite, average type, Rockall. II. "4. 1. (3) 4. Grorudose-Pantellerose.
3. Microgranitic inclusion with ægirine and laneite (blue soda-amphibole), Rockall. III. "5. 1. 4. Pienarose.
4. Ægirine-granite, mesocratic variety, Rockall. III. 3. 1. 4. Unnamed subrang.
5. Ægirine-granite, mesocratic variety, Rockall. "III. "3. 1. 4. Unnamed subrang.
6. Rockallite, Rockall. II (III). 3. 1. 5. Rockallose (unnamed subrang).
7. Rockallite, Rockall. Anal. H. S. Washington, *Q.J.G.S.*, lxx, 1914, p. 297. "III. 3. 1. 5. Rockallose.
8. Rockallite, Rockall. Anal. C. J. S. Makins, J. W. Judd, *Trans. Roy. Irish Acad.*, vol. xxxi, 1897, p. 54. (II) III. (2) 3. 1. 5. Rockallose.

These analyses are arranged in order of increasing soda-potash ratio. The series becomes persodic with increasing richness in mafic minerals (i.e. ægirine). The amount of potassic felspar has thus an inverse relation to that of ægirine, while albite increases with that mineral. In the normal ægirine-granite albite is partly displaced by microcline.

Rockallite, defined as a mesocratic (mafelsic) persodic granite, composed of ægirine, quartz, and albite, in nearly equal proportions, is thus reduced to the status of a small differentiation-facies or basic segregation in an ægirine-granite. Lacroix compares the Rockall intrusion especially to the occurrence of Ampasibitika, North-West Madagascar, and to that of Ota, near Evisa, Corsica. The Madagascan example forms an abundant group of dykes of riebeckite- and ægirine-granites, often mesocratic, and containing

zircon and eucolite. The mesocratic type has been called *fasibitikite*. Some of these dykes have a normal texture; others are pegmatitic; whilst many have a banded structure. Occasionally, the banded types have a pegmatitic centre with large riebeckite crystals and with a fine-grained or medium-grained ægirine-granite on the margins. In other cases the rock is of uniformly finer grain, and is formed of alternate bands, not rigorously parallel to the margins of the dyke, but developed in sinuous lines. The bands may be whitish, and are then quartzo-felspathic; or green because of abundance of ægirine. The latter mesocratic parts contain abundant zircon and eucolite, which is ceriferous. In the definition of fasibitikite Lacroix lays stress on its *lujavritic* structure; i.e. the ægirine crystals are arranged fluidally, as in the lujavrites (eudialyte-nepheline-syenites) of the Kola Peninsula.[1]

The same features are also found in the well-known soda-granites of Evisa, Corsica. The riebeckite-granite of Ota is traversed by thin dykes of a very fine-grained variety, containing streaks in which the mafic mineral is ægirine and the felspar albite. Niggli has given the name *evisite* to those rocks of Evisa which have previously been variously named as riebeckite-granite, riebeckite-syenite, ægirine-granite, and ægirine-syenite.[2] It is also the name of one of the *magmas* of his recent classification of igneous rocks.[3] Evisitic magmas form soda-granites, with low potash and lime, high iron, especially Fe_2O_3, and magnesia.

Thus we have now three names, rockallite, fasibitikite, and evisite, for what are, both chemically and mineralogically, essentially identical rocks. Since it is hardly worth while to base a new name on mere textural or structural differences, so that fasibitikite is scarcely needed on that account, rockallite has the priority of these three names. The further nomenclatorial difficulty enters that the name rockallite has been given, not to the dominant rock of Rockall, but to a mere differentiation-facies or basic segregation. Lacroix suggests that the term rockallite should apply to the whole heterogeneous complex of ægirine-granite on Rockall, which tends towards mesocratic types, and finally becomes quite mesocratic and then persodic.[4]

Rockall is the culminating point of a submarine ridge or bank which, defined by the depth of 600 feet, measures about seventy miles by thirty miles. Rocks have been dredged from it by fishermen and by various expeditions, and have been described by Forbes[5] and Cole.[6] The latter author describes them mainly as basalts, with some andesites, and believes that they are derived

[1] *Minéralogie de Madagascar*, t. ii, 1922, p. 596.
[2] *Gesteins- und Mineralprovinzen*, Bd. I, Einführung, 1923, p. 102.
[3] Besides the above reference, see also Niggli, *Lehrbuch der Mineralogie*, 1920, pp. 488–99.
[4] *Minéralogie de Madagascar*, t. ii, 1922, p. 596.
[5] *Proc. Roy. Soc. London*, vol. xviii, 1870, p. 491.
[6] *Trans. Roy. Irish Acad.*, vol. xxxi, pt. iii, 1897, p. 59.

from a submerged basaltic plateau which forms part of the Thulean province. The Charcot dredgings of 1921 and 1922 have procured numerous specimens of basalts (95 per cent of total number), along with trachyte and a few of ægirine-granites generally similar to the Rockall types. The analysis of the trachyte shows that it is chemically similar to the ægirine-granites, and also to the paisanite of Ailsa Craig, of which a new analysis is given by Lacroix in the third of the papers by him mentioned in the preliminary references (p. 19).

The basalts obtained by the Charcot expeditions differ from those studied by Cole in that they are not vesicular and are devoid of zeolites. They are fine-grained compact lavas in which ophitic texture is very frequent. The amount of olivine is usually small, and occasionally nil. The analysis given (see Table II below) shows that the rock is a basalt similar to those of North-West Europe in general, i.e. the Thulean province. It is very close to the average Hebridean basalt as calculated by Washington.[1] Lacroix concludes that the bank consists of a basaltic plateau similar to those of Skye, Mull, and Antrim, which is traversed by granitic intrusions of the same nature as that of Rockall.

TABLE II.

	1	2
SiO_2 . . .	48·41	45·24
Al_2O_3. . .	16·15	13·36
Fe_2O_3 . .	1·39	5·32
FeO . . .	8·61	10·64
MgO . . .	7·12	5·22
CaO . . .	11·83	9·66
Na_2O . .	2·34	3·52
K_2O . . .	·60	·91
H_2O+ . .	·95	1·93
H_2O- . .	·27	·89
CO_2 . . .	·91	—
TiO_2 . . .	1·19	3·21
P_2O_5 . . .	·22	·41
MnO . . .	·18	—
S	·12	—
SO_3 . . .	tr.	—
	100·29	100·31

1. Olivine-gabbro, Porcupine Bank, Lat. N. 53° 27′, Long. 13° 27′, off west coast of Ireland. Anal. G. S. Blake. G. A. J. Cole and T. C. Crook, op. cit., p. 8. III. 5. 4. 4 (5). Auvergnose.

2. Andesitic Basalt, Rockall Bank. Anal. Raoult. A. Lacroix, *Comptes Rendus*, Paris, t. 177, 1923, p. 440. III. 5. 3. 4. Camptonose.

In connexion with the above it should be noted that about 80 per cent of the numerous stones dredged from the Porcupine Bank, in the Atlantic, about 130 miles west of Cleggan, co. Galway, Ireland,

[1] "Deccan Traps and Other Plateau Basalts": *Bull. Geol. Soc. Amer.*, xxxiii, 1922, p. 789.

consist of an olivine-gabbro.[1] Professor G. A. J. Cole and Mr. T. C. Crook consider that these probably represent fragments from a subterranean intrusion of the magma which appears in the form of basalt further north. The analysis which is given of this rock agrees quite well with that given by Lacroix of a basalt dredged from the Rockall bank. It differs only in those features (higher lime and alumina and smaller alkalies, indicating greater felsicity and more basic plagioclase) which normally distinguish gabbros from the corresponding basalts. The analyses are given in Table II for comparison.

Some New Ordovician and Silurian Fossils.

By F. R. Cowper Reed, Sc.D.

(PLATE III.)

FROM time to time during the last fifteen years the specimens described below have been put into my hands for determination and description. In the hope of obtaining better specimens, which would explain more fully their structure and affinities, the publication of any notes on them has been repeatedly deferred, but further delay seems undesirable.

Genus Tryblidium Lindström.

Tryblidium girvanense sp. nov. (Pl. III, Figs. 1, 1*a*, 2.)

Shell oval, about two-thirds as wide as long, bluntly pointed at apex, and forming a low depressed oblique cap. Surface gently convex, most so towards apex, which is pointed at about 60° and slightly overhangs margin; shell marked with several strong concentric sublamellose rugæ, and closely placed equidistant thin sharp raised lamellæ which are of equal strength and thickness and undulate and interlace with considerable regularity, forming a reticulation of small transversely lozenge-shaped or subtriangular meshes of fairly uniform size in irregular concentric rows. Interior of shell with a posterior marginal rounded thickening on each side of apex, and with an oval thickened ring reaching about half the length of shell and composed in front of small indistinct muscle-scars. On each side below the apex the marginal thickening is transversely striated, and the apical slopes above it are rather coarsely pitted.

Dimensions.—Length, 21 mm. Width, 14 mm.

Horizon and locality.—Mulloch Hill Group, Mulloch Wood, Girvan (Mrs. Gray's Coll.).

Remarks.—The Gotland species *T. reticulatum* Lindström[2] bears a considerable resemblance to our species, but has much fewer as well

[1] "On Rock-specimens dredged from the floor of the Atlantic off the coast of Ireland, and their bearing on Submarine Geology": *Mem. Geol. Survey Ireland*, 1910, pp. 36.

[2] Lindström and Angelin, *Fragmenta Silurica*, 1880, p. 15, t. x, figs. 7–16; t. xix, figs. 9–12. Lindström, *Silur. Gastrop. Pterop. Gotland*, 1884, p. 55, pl. i, figs. 25–31; pl. iii, figs. 1–5.

as coarser lamellæ. Only one specimen of this new Girvan form is available for study, but we have, fortunately, its internal cast as well as its external impression.

Tryblidium kilbridense sp. nov. (Pl. III, Figs. 3, 3*a*, 4, 4*a*, 4*b*.)

Shell elongate-obovate, widest at about two-thirds its length, narrowing anteriorly to apex; surface gently convex, with depressed submarginal subacute apex slightly overhanging and projecting beyond margin. Surface of shell ornamented with numerous concentric lamellæ, thin, sharp, salient, imbricating, crossing each other and reticulating near middle of shell so as to form transversely elongate meshes of fairly regular size; fine equidistant regular radial striæ developed on lamellæ on anterior two-thirds of shell, but not continuous across the concentric rows of lamellæ; two or more low rounded concentric growth-ridges towards posterior end; whole margin thickened internally. Interior with pair of transverse rostral scars situated below and in front of apex, and with indistinct traces of large oval ring composed of small subcircular muscle-scars (in 4–5 pairs) arranged concentrically to the margin and extending about half the length of shell.

Dimensions—	I.	II.
Length .	18·0 mm.	18 mm.
Width . .	13·5 ,,	13 ,,
Height . .	5·0 ,,	5 ,,

Horizon.—Finny School Beds (Llandovery), Kilbride Peninsula, Co. Mayo.

Remarks.—The material on which this new species is founded consists of one internal cast and the external impression of the same shell, and one isolated internal cast. The species was mentioned as *Tryblidium* sp. nov.[1] in Messrs. Reynolds and Gardiner's paper in 1912.

It differs from *T. girvanense* in the possession of radial ornamentation on the lamellæ, and in the latter being more regular and concentric in arrangement, interlacing and crossing only in the anterior half of the shell and not forming such a fine reticulation.

Genus Gyroceras De Koninck.

Gyroceras ? *obliquistriatum* sp. nov. (Pl. III, Figs. 6, 6*a*.)

Shell cornucopiate, composed of rather more than one volution, forming cone coiled in one plane; apical portion very slender, curved into loose discoid spiral, rapidly expanding towards mouth; outer portion nearly straight. Whorls subelliptical in cross section, higher than wide, somewhat flattened on sides, dorsally and ventrally rounded, without carina or impressed zone; surface annulated by strong angular narrow rings of equal strength, the first 3–4 near mouth at subequal distances apart, the rest becoming rapidly closer together with the decrease in the diameter of the

[1] Reynolds and Gardiner, *Q.J.G.S.*, vol. lxviii, 1912, p. 86.

whorls, but all set apart at a distance approximately equal to the successive transverse diameters of the shell and bending back slightly on the dorsum to form a small shallow lobe; interspaces concave, ornamented with fine, closely placed regularly thread-like concentric lines minutely granulated and directed backwards obliquely to the rings, so as to meet them in the first 3–4 interspaces near the mouth at very acute angles (about 10°–15°), but in the others in the smaller part of the shell at increasingly larger angles up to 45°.

Dimensions.—Height of whole shell, 10·5 mm. Dorsiventral diameter at mouth, 5·0 mm.

Horizon.—Balclatchie Group.

Locality.—Balclatchie, Girvan (Mrs. Gray's Coll.).

Remarks.—This small shell is represented by only one well-preserved specimen, partly embedded on its left side in matrix, but its right side and part of the dorsum are well seen, and the fine ornamentation is very distinct. The impression of the surface of this specimen is also preserved, so that the external characters are fairly well known. The internal structure is, however, impossible to ascertain, but we may with much probability refer it to the genus *Gyroceras*. The ornamentation is much like that in some Cycloceratids, especially *Protocycloceras*, but it must rather be referred to the Plectoceratid group of Hyatt. Certain of the shells which Blake refers to *Cyrtoceras* and *Trochoceras*, e.g. *C. extricatum* Blake [1] and *T. undosum* Sow.,[2] from Silurian horizons, bear a superficial resemblance, but we may doubt their true affinity with our shell.

Genus Actinodonta Phillips.

Actinodonta mendipensis sp. nov. (Pl. III, Figs. 5, 5*a*.)

Shell transversely elongated, about 2½ times as long as high, narrowing and compressed posteriorly, bluntly pointed behind, rounded anteriorly. Cardinal margin behind umbo nearly straight, with narrow elongate lanceolate ligamental area, and passing almost imperceptibly into long very obliquely truncated gently arched posterior margin inclined to inferior margin at about 30°, but arching down to meet it at the post-inferior angle at 75°; inferior margin long, very slightly arched in a simple continuous curve, bending up in front into the rather sharply rounded broader anterior end. Umbo low, broad, obtuse, directed forwards, situated at about one-fifth the length of the shell from front end. Surface of valve rather strongly convex, most so along the strong straight subangular umbonal ridge which runs obliquely back from umbo to post-inferior angle; surface of valve above ridge flattened, becoming near umbo nearly at right angles to general surface below umbonal ridge, which is rounded and gently convex. Hinge-line with two long, thin narrow parallel post-umbonal lateral teeth

[1] Blake, *Brit. Foss. Cephal.*, 1882, p. 183, pl. v, fig. 11 (non 10).

[2] Ibid., p. 226, pl. xxx, fig. 6 (non 5).

reaching whole length of hinge-line, and with two much shorter slightly divergent pre- and subumbonal teeth, the inner one curved and short, the outer one elongated and straight and extending forwards to middle of anterior muscle-scar nearly parallel to hinge-line. Pallial line and posterior muscle-scar invisible. Anterior muscle-scar oval, slightly oblique, situated close to upper anterior margin, well marked, with strong curved ridge behind it uniting above with thick but small hinge-plate in which is deeply sunken the small pedal muscle, forming a pit between the umbo and the top of the anterior muscle-scar. Ornamentation of surface unknown.

Dimensions.—Length, 50 mm. Height at umbo, 20 mm.

Horizon and locality.—Lower Wenlock, Stoke Lane, Mendips.

Remarks.—There is only one internal cast of a right valve of this species, which Professor S. H. Reynolds collected in 1907, but it was not described with the rest of the fauna in that year [1] or in 1912.[2] Fortunately, the characters are well preserved on the whole, though immediately below the beak the matrix obscures the hinge where there is probably more than the one curved subumbonal tooth above described.

We may refer this shell to the genus *Actinodonta* Phillips,[3] and compare it with the type species *A. cuneata* Phill. (op. cit.) from the Silurian of Marloes Bay and Freshwater East. But the genus was very incompletely defined by its founder, and the type specimens cannot be found. Many palæontologists consider it synonymous with *Lyrodesma* Conrad, of which the Ordovician shell *L. planum* Conr.,[4] from New York, is the type-species. But we may greatly doubt this identification, for Phillips in describing *A. cuneata* particularly mentions two elongated laminiform teeth on the posterior slope, and they are clearly shown in his figures, while Ulrich [5] in his revised definition of *Lyrodesma* does nor allude to any such teeth, and states that the dentition consists of a median group of 6–8 transversely striated teeth radiating from the beak. Pedal muscle-scars are on the other hand expressly noted as characteristic of *Lyrodesma*, the anterior one being situated precisely as in our shell. Miss B. H. Stewart,[6] in her remarks on the character of Conrad's genus, particularly mentions two pairs of small pedal muscles. The presence of two posterior laminiform lateral teeth in *A. cuneata* Phill. seems to be of generic importance and to separate it from all members of *Lyrodesma* sens. str.

A large series of Silurian lamellibranchs which have recently been collected by Mr. D. Gibby at Marloes Bay have been examined

[1] Reynolds, *Q.J.G.S.*, lxiii, 1907, pp. 217–38.

[2] Id., *Proc. Bristol Natur. Soc.*, ser. iv, vol. iii, pt. ii, 1912, pp. 76–82.

[3] Phillips, *Mem. Geol. Surv. Great Brit.*, vol. ii, pt. i, 1848, Palæont. App., p. 366, pl. xxi, figs. 1–4.

[4] Hall, *Palæont. New York*, vol. i, 1847, p. 302, pl. lxxxii, figs. 11*a–b*.

[5] Ulrich, Lamellibr. (*Palæont. Minnesota*, vol. iii, 1894), p. 608.

[6] B. H. Stewart, "Stratigr. and Palæont. of Toronto," pt. i, p. 26 (29th Ann. Rept. Ontario Dept. Mines, vol. xxix, pt. vi, 1920).

by me, but no specimens possessing the characters of Phillips' *Actinodonta* have been recognized amongst them.

Externally, our specimen has much the appearance of "*Cypricardia*" *silurica* Eichw.,[1] but the internal characters of this species have not been described, and, in defining the genus *Cypricardinia* Hall [2] states that while one valve has a lateral tooth no cardinal teeth have been observed. *Sphenotus* Hall [3] apparently possesses a dentition rather like that seen in our Mendip shell, but typically it has a median sulcus crossing the surface, and the inferior margin also is sinuated. Chapman [4] has described a Silurian example of this Devonian genus from Victoria, but its relation to our shell is doubtful.

Genus Rhizophyllum Lindström.

Rhizophyllum ? tortworthense sp. nov. (Pl. III, Figs. 7, 7*a*–*c*.)

Corallum simple, semiconical, having one side (ventral) flattened and vertical, so that the antero-posterior apical angle of its base is about 60°, but the transverse apical angle is about 90°. Dorsal side rounded; lateral angles rounded; ventral side flattened. Calyx deep, conical, marked internally with numerous low rounded closely placed raised septal lines of equal or nearly equal thickness about 150–180 in number, half of which are primary, but all bearing a series of nearly contiguous small tubercles in a single row becoming fainter or obsolete in centre of calyx. Ventral side of calyx furnished with two low rounded thickened submedian continuous ridges extending from tip to centre but not interrupting the succession of septal lines; dorsal side with short isolated opposite median ridge only developed towards lip of calyx.

Dimensions.—Depth of calyx . . *c.* 17 mm.
Transverse diameter . *c.* 21 ,,
Anteroposterior diameter *c.* 16 ,,

Horizon and locality.—Upper Llandovery, Middlemill, Tortworth, Glos.

Remarks.—The above description is based on one specimen which was obtained by Professor S. H. Reynolds in 1908 [5] from beds containing a characteristic Upper Llandovery fauna. The true nature of this fossil is even now a matter of some uncertainty, but the conclusion has been reached that it may be regarded as the internal cast of the calyx of a species of *Rhizophyllum*, the radial tuberculated lines on the surface representing the so-called septal striæ or lamellæ. The calyx was apparently very deep and probably extended nearly to the base as in *Calceola*. An internal cast of the

[1] Eichwald, *Leth. Ross.*, Palæoz., 1855, p. 1010, t. xxxix, fig. 5.
[2] Hall, *Palæont. New York*, vol. v, pt. i, Lamellibr. II, 1885, p. xlvi.
[3] Ibid., p. xxxiii.
[4] Chapman, Mem. Nat. Mus. Melbourne, No. 2, *Silur. Bic. Mollusca Victoria*, 1908, p. 19, pl. i, fig. 10.
[5] Reynolds and Reed, *Q.J.G.S.*, lxiv, 1908, p. 519.

calyx of the Devonian coral *Calceola sandalina* would show much the same general characters as our fossil.

Our fossil does not seem very closely allied to any of the species of *Rhizophyllum* described by Lindström [1] from the Scandinavian Silurian, but we know nothing of the external features or internal structure of its corallum. The Australian species *Rh. interpunctatum* De Koninck [2] seems to approach it more closely; the rudimentary condition of the septal lamellæ and the presence of spines on their free inner edges are particularly mentioned by Etheridge.[3] The septal lines seem to be in part long and in part short, the former running from the centre of the calyx to the lip, the latter being intercalated and apparently arising about half-way up the slopes of the cup, but the arrangement is not quite regular, and there is some trace of a grouping of the radial lines and a slight strengthening of the primaries near the upper edge of the calyx. (The specimen has been drawn on the plate in an inverted position.)

EXPLANATION OF PLATE III.

FIG.

1.—*Tryblidium girvanense* sp. nov. Impression of exterior of shell. × 2. Mulloch Hill Group, Mulloch Wood, Girvan.

1*a*.—Ditto. Portion of surface of same. × 5.

2.—Ditto. Internal cast of same specimen. × 2.

3.—*Tryblidium kilbridense* sp. nov. Impression of exterior of shell. × 2. Llandovery, Kilbride Peninsula, Co. Mayo.

3*a*.—Ditto. Portion of surface of same. × 5.

4.—Ditto. Internal cast of same specimen. × 2.

4*a*.—Ditto. Apical view of same. × 2.

4*b*.—Ditto. Lateral view of same. × 2.

5.—*Actinodonta mendipensis* sp. nov. Internal cast of right valve. × 1½. Lower Wenlock, Stoke Lane, Mendips.

5*a*.—Ditto. Cardinal view of same specimen. × 1½.

6.—*Gyroceras*(?) *obliquistriatum* sp. nov. × 2½. Balclatchie Group, Balclatchie, Girvan.

6*a*.—Ditto. Portion of same. × 8.

7.—*Rhizophyllum* (?) *tortworthense* sp. nov. Side view. × 1½. Upper Llandovery, Middlemill, Tortworth, Glos. (The specimen is drawn in an inverted position, and as it is in the condition of an internal cast the septal striæ and spines show as grooves and pits.)

7*a*.—Ditto. Posterior view of same. × 1½.

7*b*.—Ditto. Portion of surface of same. × 4.

7*c*.—Ditto. Ditto. × 8.

P.S.—Since the above notes went to press my attention has been called to two papers by Barrois [4] and Douvillé [5] which have dealt with the question of the genus *Actinodonta*. Both these

[1] Lindström, *Bih. k. Svensk. Vet. Akad. Handl.*, Bd. vii, No. 4, 1882, pp. 22–40.

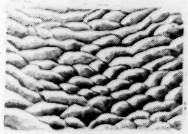
[2] De Koninck, *Foss. Palæoz. Nouv. Galles*, 1876, p. 61, t. i, fig. 10; Etheridge, jun., *Rec. Australian Museum*, vol. i, No. 10, 1891 (Sydney), p. 203, pl. xxx, figs. 7–15.

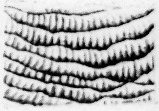
[3] Etheridge, jun., Mem. Geol. Surv. N.S. Wales, Palæont., No. 13, 1907, *Mon. Silur. Dev. Corals*, pt. ii, Genus *Tryplasma*, p. 70.

[4] Barrois, *Ann. Soc. Géol. du Nord.*, xix, 1891, pp. 164–76.

[5] Douvillé, *Bull. Soc. Géol. France*, ser. iv, vol. xii, 1912, p. 440, text-figs. 10–12.

1 2 3



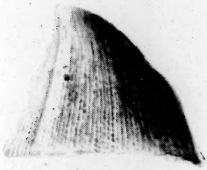


3*a*

4*a*

4

4*b*



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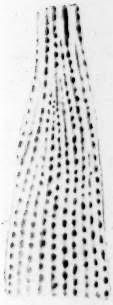
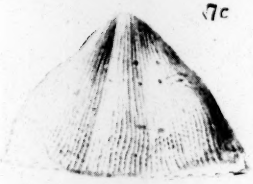
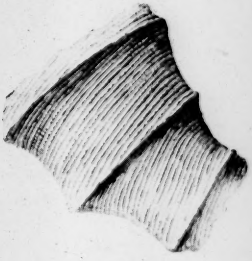


5*a*

7*c*





7*a* 6 6*a*

T. A. Brock del.

New Ordovician and Silurian Fossils.

[To face p. 30

authors accept without hesitation the generic validity of this name, and the former describes several new species referable to it from the Armorican Grit of Brittany, but we may doubt if he is correct in putting *Anodontopsis* McCoy as a synonym. *Lyrodesma* is defined as a distinct genus. My independent conclusion is thus found to have been anticipated.

The Separation of the Continents by Fission.

By Professor W. H. Pickering, Harvard College Observatory.

SINCE this subject is now again under discussion by geologists, it may be of interest to recall that in my original paper, published in the American *Journal of Geology*, 1907, vol. xv, p. 23, and republished and revised in *Harper's Monthly*, 1907, vol. cxv, p. 120, and in the *Scottish Geographical Magazine*, 1907, p. 523, this separation was attributed to the great convulsion that occurred at the time of the birth of the Moon, from the side of the Earth. This explanation of the origin of our Moon is at the present time almost universally accepted by astronomers. We see the same phenomenon occurring in many close double stars.

The bed of the Pacific was suggested as the scar due to this convulsion, and the Atlantic as the crack caused by the splitting of the remaining land surface into two portions, and their being drawn apart at that time. The theory was criticized formerly by those who thought that the separation occurred so long ago that at that time the whole surface of the Earth must either have been liquid rock or the whole mass gaseous, so that no scar could have been left.

During the past sixteen years, however, astronomy has advanced so far that we now know that the day is lengthening by tidal action at the rate of about one second in 100,000 years. When the material now forming the Moon was cast off, the period of rotation of the Earth on its axis was three to four hours. Therefore, if the lengthening of the day since then had been at a uniform rate, this event would have occurred about seven thousand million years ago. This, however, must be taken as a maximum figure, for when the Moon was near the Earth, the lengthening of the day would have occurred far more rapidly than at present, and if we divide this figure by ten we shall reach a much more probable date for the great catastrophe, but as we shall see later, still a maximum.

We now know from measurements of the radioactivity of the oldest granites obtainable, that these had already solidified at some time between one thousand and ten thousand million years ago. It is, therefore, practically certain that the original surface of the Earth, which may have been older yet, was solid at the time of the birth of the Moon. If such was the case, such a catastrophe must have left a terrible scar, and the only such mark that we find is the bed of the Pacific.

In my original paper I placed the centre of origin at about 1,000 miles north-east of New Zealand. I have since modified this statement by saying that the northern point of New Zealand itself was the last point of contact. It must not, however, be supposed for a moment that the Moon left the side of the Earth a perfect sphere, as we see it to-day. Three-quarters of the Earth's surface, to a depth of 35 miles, was carried away in a trailing mass of ruin. New Zealand itself was just saved to the Earth. From the Straits of Gibraltar, diametrically opposite to New Zealand, another piece stretching out into the bed of the Atlantic, almost necessarily followed the rest, and a ring of debris surrounding the Earth was thus formed analogous to the ring of Saturn.

It is the piece that followed from the bed of the Atlantic that is of interest in the present discussion. That the forcible and sudden removal of such a piece, a thousand or more miles in diameter, would crack the continental surface in several directions is most probable. Allowing for its removal, the two sides of the Atlantic then match one another perfectly, as is shown in my original paper.

Wegener has recently modified my suggestion by stating that instead of occurring in Archæan times, the separation of the continents took place as late as the later Cretaceous, or early Tertiary. This suggestion appears to please the geologists better than the other, but it has corresponding difficulties. That great surface changes occurred between the lower and upper Cretaceous periods is well known, but that a catastrophe involving the sudden removal of three-quarters of the Earth's surface could occur without destroying all life, both vegetable and animal, appears impossible.

If the Moon carried off so large a portion of the Earth's surface, it is easy to understand that it could have parted the rest and drawn it apart. That under similar conditions similar geological formations prior to the Cretaceous might be deposited on opposite sides of the Atlantic seems probable, and even nearly identical forms of animal life might be developed. At least this seems more plausible than that the birth of the Moon should have occurred during Cretaceous times.

Of course, the crack between the continents might have been formed at the birth of the Moon, and the two continents have been left in close proximity until much later. It is clearly for the true interest of science for each branch to throw out a helping hand when possible to every other one. Therefore let us now see what can be done by astronomy in support of Wegener's modification of my suggestions.

It has been shown in *Popular Astronomy*, 1919, vol. xxvii, pp. 246 and 498, that the fragments of the Earth, which were ultimately to form the Moon, did not coalesce at once into a single body, but remained as a ring of separate fragments for many hundreds of millions of years. In the meantime, during the slow process of polar inversion, due to the annual tide produced by the Sun on the disc-like form of the Earth, its axis shifted from the original inverted

position until it coincided with the plane of its orbit. The ring at the same time shifted with it, and when its plane was perpendicular to the orbital plane then was the time when the fragments could most readily coalesce to form our Moon. At this time, as the pieces gradually came together and retreated from the Earth, the lunar tides began, tides that on account of the close proximity of the Moon were of such enormous intensity that had they occurred in oceans of sufficient depth they would have risen to a height of several miles, instead of only a few feet as is the case at present. That they were several hundred feet in height seems very probable. That such tides would have produced great changes in the Earth's surface and maintained enormous areas temporarily under water, is certain. That volcanic activity should have been intense, while a temperate climate reached the polar regions under the vertical summer sun is also clear. It is true that the polar nights would still have been six months in length, but the vertical sun would largely reduce the ice caps and their summers would have been greatly modified. All this is believed to have occurred in the Cretaceous period. The solar annual and lunar monthly tides combined have since brought the Earth's axis to its present inclination.

This applies to either belief as to the period of shifting of the continents. According to Wegener this was the time when the continents began shifting westward. If this shift was due to the action of the Moon, and there seems to be no other possible cause, then the date he has fixed is certainly an appropriate one. But could the Moon produce such an effect? The continents at this time were anchored in solid rock covered by our oceans, not floating in a liquid magma, as was the case at the birth of the Moon.

We cannot imagine two ice floes drifting apart because of tidal action, unless there were ocean currents in existence produced by the tides. But there are no such currents occurring in the rocky floors of the oceans. If such a shift does occur, however, in spite of what we think is possible to the contrary, it is to be noted that it does not need to be very marked. In order to cause a shift of 3,000 miles in an interval of sixty million years, a plausible date for the Cretaceous age, a separation of only 3 inches per year is involved. This certainly does not seem impossible if there is anything to cause it, but it must be remembered that if one continent is shifting, it is likely that the other one is doing so also, so that the 3 inches is simply a difference of shift.

It is true, that as pointed out by Turner, if the longitude observations made in Greenland in 1870 and in 1907 are both correct, that island has shifted westward in thirty-seven years some 4,000 feet. The observations should certainly be repeated, but until that has been done we must feel some scepticism with regard to them. This westerly shift of the continents was also suggested by Schwarz, who refers it to the daily heating of the Earth's crust (GEOL. MAG. 1909, p. 145). If the irregularities in the observed motion of the

Moon are due to a slip of the continents relative to the Earth as a whole, as suggested by Eddington, then we have fallen back about 700 feet in a few decades from our previously determined average position, in addition to our average annual slip, and are expected later to make it up again by a slower rate of slip. It does not seem possible that our present ocean tides, acting chiefly on small enclosed areas like the Irish Sea, can produce any such effect. These are arguments for and against Wegener's suggestion from an astronomer's point of view, and we can only say that while it may have occurred, we see no adequate cause for such a shift during the last sixty million years.

The question of the Permian ice age still seems to be worrying the geologists. To the astronomer a simple explanation, and possibly the true one, is obvious. At the present rate of motion of our Sun, 12 miles per second, we should traverse a distance equal to that between us and the nearest star, Alpha Centauri, in 60,000 years. In the few thousand million years of terrestrial independence, the Sun is likely to have traversed several of the many nebulous clouds scattered through space. One of these may have been encountered during the Permian period. In the immediate vicinity of the Sun this cloud would have been somewhat heated, more by the presence of the Sun itself than by the friction of its motion, but in the ninety millions of miles separating us from the Sun, the nebula could easily have absorbed as much as 20 or even 30 per cent of the solar heat and light. This would have been ample to have produced the effects observed.

MANDEVILLE, JAMAICA, B.W.I.
12th October, 1923.

REVIEWS.

FOSSIL PLANTS OF THE CARBONIFEROUS ROCKS OF GREAT BRITAIN. By R. KIDSTON, LL.D., D.Sc., F.R.S., L. and E. Mem. Geol. Surv. Palæontology. Vol. II, Parts I, II, III. 1923. (Part I, 15*s.*; Part II, 12*s.* 6*d.*; Part III, 12*s.* 6*d.*)

THE Ministry of Agriculture and Fisheries, in giving notice of the proposed publication of a Memoir on Carboniferous plants, draw attention to the imperative necessity for research in relation to the manifold problems connected with our coal-bearing strata, and emphasize the need for an authoritative Monograph on the vegetation. In 1848 Sir Joseph Hooker, during his brief association with the Geological Survey, contributed to the official Memoirs a contribution "on the vegetation of the Carboniferous period as compared with that of the present day"; since then, the Survey publications have not been conspicuous as repositories of palæobotanical data. Both the Ministry and the Director of the Geological Survey are to be congratulated on the policy which they have now adopted. The claims of Palæobotany have been handsomely, it can hardly be said prematurely, recognized. The gathering together of the materials for such a Memoir as is now in course of publication "has been a task demanding a life-time of patient and continuous investigation, and the Geological Survey is fortunate in having at its disposal the labours of such a distinguished palæobotanist as Dr. Kidston".

The Memoir is to be published "in about ten parts, and each part will have from 20 to 30 plates". There is no one in this or any other country who has either the experience or the knowledge of the subject that Dr. Kidston possesses. Both botanists and geologists are deeply indebted both to those who are responsible for this forward step and to the author for having consented to undertake a particularly difficult and arduous piece of work.

Part I begins with a useful and concise summary of the progress of palæobotanical research in Great Britain: "the revival of the study of fossil botany in Britain began about 50 years ago, and has steadily pursued its upward path." The author might have extended the period by twenty-five years, as Hooker's important paper, to which reference has already been made, was published seventy-five years ago. In the section on "British Carboniferous rocks" allusion is made to the generally recognized value of plants in determining zones in the Coal Measures, and a very welcome summary is added of the results of investigations by geologists and palæobotanists. It is primarily through Dr. Kidston's own researches that it has been possible to correlate the productive strata in the several British coalfields. The third section of Part I, entitled "Ferns and Fern-like Plants", traces our knowledge of

the nature and affinities of the numerous fronds and other organs which were borne by plants the majority of which, though fern-like in appearance, were members of a group that is now extinct. The first genus mentioned in this section, the genus *Myeloxylon*, is of special interest at the moment because in two recently published papers by American authors, one in the *Journal of Geology* and the other in the *Botanical Gazette*, a specimen, which is undoubtedly a *Myeloxylon*, was incorrectly described as a Palæozoic Angiosperm. *Myeloxylon* is the name given to petioles of different species of *Medullosa*, one of the best known genera of Pteridosperms, plants with fern-like foliage which produced seeds and in the structure of the stems differed widely from true ferns. Dr. Kidston gives a brief account of the steps by which our knowledge of Pteridosperms has been acquired, and adds "it is well known that true Ferns existed side by side with Pteridosperms". The difficulty, as he states, is to distinguish between Ferns in the strict sense and Pteridosperms. The fronds alone are not sufficient, and even well-preserved sporangia do not always afford decisive evidence. "Irrespective of any question as to whether Ferns or Pteridosperms were most numerous in Carboniferous times, the most interesting fact is that at the base of the Carboniferous Formation there existed side by side, both Ferns and Pteridosperms."

The sections to which reference has been made are followed by descriptions of species, clearly written and crowded with facts; and it is by these descriptions that the value of the Memoir must be determined. *Sphenopteris* is the genus selected for treatment in Part I: it is one of several form-genera founded on the characters of sterile fronds which in themselves do not determine the precise botanical position of the plants to which the leaves belong. A full diagnosis is followed by remarks and supplementary descriptions which give the information required for correct identification and by a full list of localities and horizons. A noteworthy feature is the list of references to records of each species in the scattered literature, including synonyms.

Dr. Kidston is his own photographer and a master in the art: the illustrations, both photographs and drawings, are excellent. The thoroughly scientific descriptions and critical discussions are invaluable to the specialist, and with the help of the well-reproduced plates the collector, who is not also a palæobotanist, should be able to identify specimens of Carboniferous Ferns and Fern-like plants with comparative ease. Tables of strata and maps showing the distribution of coalfields in England and Wales and in Scotland are added as supplementary plates.

Part II contains descriptions of additional species of *Sphenopteris*, species of *Adiantites*, *Sphenopteridium*, and other genera; Part III includes *Rhacopteris*, *Rhodea*, and two other genera.

It is obviously impossible in a single review of the three Parts to do justice to Dr. Kidston's work. The printing of the text and

the reproduction of the photographs call for a word of praise. We are grateful for what has been accomplished, and for the sake of British science we offer our best wishes to the author for the successful completion of the formidable task which lies before him. The Memoir in its completed form, provided the present standard is maintained, will unquestionably be the most complete and authoritative systematic monograph of Carboniferous plants that has ever been published.

A. C. S.

THE GEOLOGY OF LIVERPOOL WITH WIRRAL AND PART OF THE FLINTSHIRE COALFIELD: EXPL. SHEET 96. By C. B. WEDD, B. SMITH, W. C. SIMMONS, and D. A. WRAY. Mem. Geol. Survey. pp. vi + 178, with 2 plates and 6 figures. 1923. Price 4*s*.

THE appearance of the Memoir of the Geological Survey on this district was opportune in view of the fact that the British Association held its meeting in Liverpool during September. The area included in Sheet 96 comprises Liverpool and part of its suburbs, the peninsula of Wirral, and the north-eastern part of Flintshire. The fact that the eastern boundary of the sheet lies immediately east of the city of Liverpool unfortunately prevents the memoir being descriptive of the "country around Liverpool". The formations cropping out in the area and described in the memoir include the Carboniferous Limestone Series, the Cefn y Fedw Beds ("Millstone Grit"), the Upper, Middle, and Lower Coal Measures, the Bunter, Keuper, Glacial, and other superficial deposits. The geological structure and economic products of the area are also adequately considered.

Useful notes, supplementary to those of Wheelton Hind and Stobbs, are added on the zoning of the Carboniferous Limestone. In the account of the Lower Coal Measures, those interesting divisions, the Gwespyr Sandstone and the Holywell shale, upon which much work still remains to be done (particularly on the goniatites, where they are available), are accorded a good deal of attention. The development of the Middle Coal Measures, which as usual are the productive measures in Flintshire and Wirral, is described in detail. Also a correlation of the seams in the two coalfields occurring in each side of the Dee, as parts of the same basin, is attempted. It is a pity that the results of recent explorations at the Wirral Colliery could not be included. The Lancashire sequence unfortunately lies just outside the area described; we are, therefore, probably deprived of valuable suggestions regarding the correlation of the sequences in the Lancashire and Flintshire areas; so close geographically and so different geologically.

It is satisfactory to find that the Bunter sands and pebble-beds are attributed to the sweeping down of detritus by rivers from high land on to adjacent lowlands, and mention is made of a large,

rapidly-sinking deltaic area. This is akin to Barrell's illuminating conception of "intermontane basins", which was accepted by Professor Bonney for the Old Red Sandstone. The late Joseph Lomas was, apparently, being led to similar conclusions at the time of his death. The investigation of the finer material of the Bunter of Lancashire and Cheshire shows indubitably that derivation was from the north or north-west. (In this connexion the mention of andalusite on p. 70 is surely a slip.)

Much useful information on the Keuper, Glacial, and other superficial deposits has been collected together. However (and this is more noticeable in the chapter on Economic Products), certain statements, drawn up presumably before or during the war when early publication was contemplated, are hardly correct at the present time. Obviously, when the delay in publication is so great, continual revision cannot be exercised.

The Memoir provides a valuable record of new facts and a useful compilation of old ones.

P. G. H. B.

Local Geology: A Guide to Sources of Information. By A. M. Davies. pp. 16. London: Murby, 1923. Price 1*s.* net.

ALTHOUGH it is stated in a prefatory note that this pamphlet is written mainly for teachers of geography, the hope is also expressed that it will be of use to students of geology. From the last-named point of view, the title is somewhat misleading, since the outlook is almost entirely cartographical. A detailed account is given of the various maps of the British Isles published by the Geological Survey, and the accompanying memoirs are also noted. References are given to a considerable number of original papers in various publications, mostly those illustrated by maps. No mention is made of any of the special Survey memoirs, other than sheet-memoirs. Petrography, mineralogy, and the economic applications of geology are completely ignored, and we have searched in vain for any reference to the existence of such a thing as a geological bibliography. We fear this pamphlet will give even to those for whom it is ostensibly written a very incomplete view of the amount of geological information available in official and other publications on the subject.

The Geology of the Metalliferous Deposits. By R. H. Rastall, Sc.D., M.Inst.M.M. pp. xii + 508, with 81 figures. Cambridge: University Press, 1923. Price 21*s.*

THE primeval earth may be regarded, according to Goldschmidt, as a fluid globe consisting of three practically immiscible components, namely a *silicate slag*, a *sulphide matte* and *metals*, as is the case in common metallurgical practice. The slag on cooling formed the primary rock crust in which were disseminated,

more or less uniformly and in limited proportions, the various metallic elements, the subsequent segregation and concentration of which gave rise to the workable ore deposits. On the study of the methods of concentration made use of by Nature is based the genetic classification of ore deposits. In common with most modern writers on the subject, Dr. Rastall, in his book on the Geology of the Metalliferous Deposits, adopts this system. First, he divides them into the two main groups, into which they naturally fall :—

(1) *Primary Ores*, viz. those that retain the condition and position in which they have been first formed.

(2) *Secondary Ores*, viz. those that have undergone physical and chemical changes since their first formation.

In the vast majority of cases, the origin of the primary deposits is dependent upon the eruption of igneous rocks. With this as a guiding principle they can be subdivided as follows :—

(1) *Orthotectic Deposits* (genesis by direct magmatic differentiation of igneous rocks).

(2) *Pneumotectic Deposits* (genesis by magmatic fluids derived from igneous rocks and rich in mineralizers).

(3) *Hydrothermal Deposits* (genesis by ascending hot waters).

Dr. Rastall has these three classes, but does not so name them. The terminology adopted above is that suggested by recent authors.[1] Dr. Rastall also has a fourth and somewhat indefinite class, which he thus describes : " Infillings and replacements near the surface by waters of meteoric origin." It is doubtful whether under this head there are primary deposits of sufficient importance to justify the setting up of a separate class. In the main the meteoric waters give rise to secondary deposits.

There are two distinct categories of secondary ores, namely, (1) the ores formed by chemical and physical changes in the primary deposits themselves ; (2) the deposits formed by denudation and deposition in bedded deposits and residues left on the outcrop of lodes by processes of denudation. Accordingly, Dr. Rastall has three groups :—

(1) *True Secondary Deposits*, subdivided into

(*a*) oxidation ores, formed in the zone of active water circulation (the vadose zone of Posepný), and

(*b*) secondary enrichments, formed below the permanent water level.

(2) *Residual and Transported Deposits*, such as gossan, shoad, and alluvials.

(3) *Bedded Ores* formed primarily as sediments or by the metamorphism of sediments.

It will be observed that in this scheme of classification, replacements and contact deposits are not specifically distinguished from

[1] Lindgren, *Economic Geology*, vol. xvii, 1922, p. 292. Gratton and McLaughlin, *Economic Geology*, vol. xiii, 1918, p. 85.

the infillings of fissures or cavities, and this is just as well, since in practice it is often impossible to decide whether a given ore-body has been formed by the actual filling of an opening or by the metasomatism of a pre-existing rock. Often both phenomena take part in the genesis of a given ore deposit.

Again *form* plays no rôle in the scheme: the classification is genetic and not morphological. The form in which ore-deposits occur is, however, of the highest importance to the mining engineer, who must base thereon his lay-out for the development and economical extraction of the ore; and Dr. Rastall devotes a lengthy chapter to the consideration of this aspect of the subject.

Another important chapter treats of *Metallogenetic Zones*, or zonal variation in primary ores, a subject not only of considerable theoretical interest, but also of great practical importance. Thus, Cornwall—a great copper producing county 100 years ago—at the present day yields tin instead of that metal. In other words, lodes that produced copper in their upper levels yield only tin in their lowest workings. It has been definitely proved by the actual working of mines in the Camborne-Redruth area, that in that district the following metalliferous zones exist in downward succession:—

1. Silver, lead, and zinc.
2. Dominant copper.
3. Tin and copper.
4. Dominant tin, with tungsten and arsenic as subsidiary minerals.

After dealing with general principles in Part I of his book, Dr. Rastall proceeds to the description of actual occurrences. In this part the ores are dealt with under the head of their characteristic metal, the chapters being headed respectively: Copper; Tin; Lead and Zinc; Iron; Nickel, Cobalt, Manganese, and Chromium; Mercury, Antimony, Arsenic, and Bismuth; the Minor Metals; Aluminium; and the Precious Metals. The geological relations of the occurrence of each metal are brought out by the description of typical examples of mineral deposits; but no attempt is made to refer to all important occurrences. Repetition would otherwise be inevitable where there is little variation in mode of occurrence. Taking copper as an example, we find detailed description limited to the following deposits, which practically illustrate all the main modes of occurrence:—Parys Mountain, Anglesey; Moonta and Wallaroo, South Australia; the Lake Superior region; Butte, Montana; the "porphyry copper" of Bingham, Utah, Ely, Nevada, and Miami, Arizona; the limestone replacements of Morenci and Bisbee, Arizona; the cupriferous pyrites deposits of the Rio Tinto district, Spain, and of the Trondhjem and Sulitjelma districts of Norway; the Namaqualand deposits in Cape Colony; copper in sedimentary rocks (Alderley Edge, Mansfeld, Katanga).

Under iron there are descriptions of the following occurrences :— Kiirunavaara, Luossavaara, Gellivare, Grängesberg, and Routivare, in Sweden ; Ekersund-Soggendal and Sydvaranger, in Norway ; the Mesabi and Marquette ores of Lake Superior ; the low phosphorus hæmatites of Cumberland and Lancashire ; the Bessemer ores of Bilbao, Viscaya, and Santander in Northern Spain ; the Jurassic ironstones of Cleveland, Frodingham, and Northampton ; the similar ores of Lorraine ; the Clinton ores of the United States ; the oolitic ores of Wabana, Newfoundland ; the Coal Measure blackbands and clay-ironstones of Great Britain ; and the Lake ores of Sweden and Finland. Here again, the ground is succinctly but adequately covered. Dr. Rastall is to be congratulated on having completed a useful piece of work and on having produced a book that will assuredly take a high place among the standard textbooks on the subject.

F. H. Hatch.

Geological Survey of Tanganyika Territory. Final Report. By E. O. Teale, D.Sc., F.G.S. pp. 41. Waterlow & Sons. 1922.

GEOLOGICALLY, as well as geographically, Tanganyika Territory is one with Uganda and Kenya Colony ; the whole constituting a mass of very ancient land, almond-shaped in plan, cut off from the Congo Basin on the west by the crescent-shaped arc of the Central African Trough ; to the north separated from the Abyssinian Highlands by the belt of low ground which connects the Jubaland Plain with the Nile ; southwards blending with Portuguese East Africa. The geological history of this " core ", as one may perhaps term it, has been simpler than that of almost any part of Africa. Leaving the coastal belt of Mesozoic and Cainozoic sediments out of account, between the closing of the Eozoic and the commencement of the Cretaceo-Tertiary vulcanicity, the only formations of (presumed) Archeozoic age are restricted to the western part of the crystalline complex, and thereafter, outliers of the Karroo System alone represent the remainder of the geological column. The composition of the Eozoic rocks is accordingly of very considerable interest, as a resistant mass which seems to have escaped many of the vicissitudes recorded in neighbouring lands. Dr. Teale admits that the descriptions so far published " have not added much " to our knowledge of the " origin, relationship, and relative age of the various members of this great group of rocks ". In this Report evidences are given of an extensively spread series of completely metamorphosed sediments, no doubt the southerly continuation of the Turoka Series, and of the various members crystalline limestones are perhaps the most important. Additional work may quite disprove the suggestion, but there appears a tendency for the outcrops to occur about the 38th degree of longitude ; e.g.

near Mikesse and Handeni. Dr. Teale gives very little information about the direction of foliation, but if it varies, as in Kenya Colony, only inconsiderably on either side of north and south it is interesting to note the occurrences near the Uganda Railway and beyond. Marble is found to the west of Voi, between Bura and Taveta, between Tsavo and Kenani Stations, south of Thumbi and north of Mumoni (both north of Kitui) and at Langaia, north-north-east of Mount Kenya, a distance of more than 8 degrees. Of these the Voi deposits depart more than 40 miles from the meridian indicating a swing in what may prove to have been the principal zone of calcareous deposition. As a whole, the rocks appear to contain more secondary minerals than do those from Kenya Colony. Kyanite is doubtless commoner, and occurs in 37 per cent of the concentrates, and scapolite-bearing rocks are widely developed. Microcline is the dominant felspar of the gneisses, which contain garnet as an especially characteristic mineral; a difference from the majority of Kenya gneisses. Quartz-schists and massive quartzites, rather widely spread in the Turoka Series, are not mentioned from the south. Finally, hypersthene, as common as kyanite, indicates a distinction from the northern land.

Other points of interest are, a note on the "Fauna of the Lower Karroo Shales of the Kidodi District", by Dr. Smith Woodward, the failure of the analyses for oil in shale from the Tanga hinterland, the bed proving carbonaceous only, and the hopeful coal analysis. Dr. Teale notes the ash (6½ per cent) is considerably less than that of "many useful South African coals".

The work done by this temporary Survey has been of great value: that such a source of important information, economic and scientific, should be now cut off is a disappointment and a loss.

The Gold Deposits of Western Australia. By A. Gibb Maitland. pp. 92, with 98 figures and two maps.

THIS large and important memoir is in reality an extract from the Mining Handbook of the Western Australian Geological Survey, published in separate form. It includes a general statement and a detailed account of the geographical distribution and characters of all the deposits of gold found in the numerous and rich goldfields of the State. As is well known, the gold ores of Western Australia are of special interest, showing as they do the best example of the telluride type on a large scale. Ample particulars are here given of the geological features of the individual mines, illustrated by many plans, sections, and photographs: statistics of production are also given. The work will be of the greatest value to all interested in gold-mining, whether on the scientific or the technical side, and constitutes a notable addition to the already vast literature of the subject.

THE COPPER ORES OF CORNWALL AND DEVON. By H. DEWEY. Spec. Rep. Min. Res. Great Britain. Vol. xxvii. Mem. Geol. Survey. pp. iv + 73, with 4 plates and 13 text-figures. 1923. Price 2*s.* 6*d.*

THIS useful compilation carries on the general plan of this admirable series, and gives a very full account of the general features of the copper-mining districts of south-west England, with ample details of the individual occurrences. We are glad to note that the author lays special stress on geological and mineralogical relationships, and brings out clearly the well-marked zonary distribution of the copper ores. Most of the deposits appear to have been pretty well worked out, and it is unlikely that there will ever be much further development, in sharp contrast with the undoubted possibilities of tin-mining at deeper levels in the same area, especially below many of the old shallow abandoned copper mines.

ON CONCRETIONARY LIMESTONES IN GENERAL AND ON PEBBLES FROM LAKE OMEO IN PARTICULAR. By F. CHAPMAN, A.L.S. Victoria Naturalist. Vol. xl (1). 1st May, 1923. pp. 5–9, 1 plate.

MR. CHAPMAN, having made a study of various concretionary nodules from Australia, has furthered the knowledge of their organic origin. He finds those from the Mallee Bores contain shells and ostracod valves seen to be enwrapped with a finely granulated deposit which has all the appearance of a disintegrated calcareous plant-thallus, which bears evidence of its organic origin by being riddled in places by the parasitic boring fungus allied to *Achlya*. In pebbles from Lake Omeo calcareous algæ are present in considerable quantities. Some may be siphoneaceous, while others are presumably of the nature of Characeæ.

CORRESPONDENCE.

MR. S. HAZZLEDINE WARREN'S VIEWS ON THE SUBSOIL PRESSURE-FLAKING OF FLINTS.

SIR,—In reading the letter in your November issue from Messrs. Barnes and Reid Moir on the above subject, one cannot help reflecting that it is generally better to discuss the ideas put forward in a paper than to criticise the Author on his use of English.

When I read Mr. Warren's presidential address (to which your correspondents particularly refer) in the *Proceedings of the Geologists' Association*, and his previous paper on similar lines in the *Journal of the Royal Anthropological Institute*, I had no difficulty—as an Engineer—in understanding the meaning which the Author intended to convey, and I would suggest that the trouble experienced by

Messrs. Barnes and Moir may be mainly due to the frame of mind in which they approached the subject.

When, some years ago, Mr. Reid Moir published [1] a serious mechanical blunder regarding the pressures used in his experiments, his critics were more considerate. I pointed out to him, in private letters of which copies lie before me now, that in calculations relating to his screw press he had left out frictional resistance, which in the case of a fine pitched screw accounts for the greater part of the applied force.

I should not have referred to the matter now had not your present correspondents, in their letter, mentioned an article [2] in which they have this year repeated the fantastic figure of 300 tons per square inch. I would only remind your readers that, according to data published at the time,[3] this was applied over an 8-inch diameter cylinder—i.e. a total pressure of 15,000 tons—through a *rubber ram !* I am not much interested in what happened to the flints, but I should like to see that piece of rubber !

An error in the order of an experimental figure is bad enough, but it is not so serious as the fallacy involving Newton's Third Law of Motion, also repeated in the same article,[2] which is referred to in your November issue. The writers state that Mr. Warren's calculated figures of subsoil pressure due to the dead weight of superincumbent strata are not correct in sand, because (as one of them has put it) : " Pressure is not distributed vertically through sand, but is distributed largely horizontally by such a medium."

To prove this curious proposition they cite an experiment in which a column of sand in an inch-diameter iron pipe is found to jam when pressed downward by a loosely fitting plunger. This is a perfectly good experiment, but unfortunately its application to sand in bulk is all wrong.

In the first place, they have not observed that the downward thrust is there all right, though in this particular case transmitted by the tube, meeting Newton's " equal and opposite reaction " vertically upward at the jaws of the vise or other support.

In the second place, they do not investigate what happens when the rigid wall of the tube is replaced by more sand, and more outside that, till the diameter is greater than sand grains will arch or bridge across.

It is, of course, well known that a secondary effect of a vertical pressure on running sand is a horizontal thrust in all directions (this incidentally accounting for some of the underground movements postulated by Mr. Warren), but these horizontal forces balance each other, and (on the principle of the " triangle of forces ") cannot do away with the downward pressure.

I hope neither of your correspondents will regard this as a personal

[1] *Proceedings of the Prehistoric Society of East Anglia*, part ii, p. 181.
[2] *Man*, vol. xxiii, 1923, No. 74.
[3] Professor Ray Lankester in *Westminster Gazette*, 20th December, 1911.

attack. Mr. Barnes and Mr. Warren I have not the pleasure of knowing. From Mr. Moir I have personally experienced nothing but courtesy, and I have always had a high regard for his enthusiasm and sincerity. I am only sorry that he should descend to a style that will tend to discredit the views he advocates.

S. E. Glendenning.

84 Rosary Road, Norwich.
22nd November, 1923.

THE BASE OF THE DEVONIAN.

Sir,—Whilst recognizing the transitional nature of the Downtonian strata, I fear the suggestion made by Dr. Evans in your October issue to regard them as Passage Beds belonging neither to the Silurian nor to the Devonian hardly meets the case. This solution of the problem was, indeed, suggested long ago by Professor Hull (*Q.J.G.S.*, 1882, p. 200), but has met with little favour. It would not obviate the present confusion in such generalized accounts of the Silurian and Devonian faunas as appear in textbooks. It would further necessitate the separation of the equivalent beds in every part of the world.

The other points raised are answered, to some extent at least, in my recently published "Introduction to Stratigraphy", where my views on the relation between the Welsh and Cornubian Devonian are summarized (pp. 115–21). They accord almost exactly with those of Dr. Evans. Geographers do not hesitate to include as lakes such impersistent areas of water as occur in most desert regions—areas which often migrate from year to year—so surely there can be no objection to the use of the word to include "a deep mountain-girt basin into which poured raging torrents from the surrounding mountains" in Devonian times.

L. Dudley Stamp.

University of Rangoon.
3rd November, 1923.

FOSSILS FROM THE MIDLAND COALFIELDS.

Sir,—I have received several inquiries about various fossils in my collection from the Coal Measures of the Midland coalfields and about unpublished maps and sections of boreholes, to which I am unable to give a detailed reply because the collection, etc., has been boxed up and stored away for the past nine years during my absence in the desert. As I am leaving for the Far East within a few days, I request your assistance in making the following details known pending an opportunity either of completing the study begun in 1907 or of depositing the notes and collection in some public museum where they will be available to specialists.

With the exception of a few rare plants in the hands of Dr. R. Kidston, some of which have been described in part ii of memoir "Fossil Plants of the Carboniferous Rocks of Great Britain"; some

fossil footprints from the Keele Beds of Warwickshire lent to Professor H. H. Swinnerton, of Nottingham, and a few fossils that were handed to the late Dr. L. Moysey and are presumably now at Jermyn Street or at the Sedgwick Museum, the collection includes the fossils detailed in the following papers by the writer:—

1909. "Geology of the Lower Coal Measures of Derbyshire and Nottinghamshire": GEOL. MAG., pp. 289–99.

1910. "The Fossil Flora and Fauna of the Southern Portion of the Derbyshire and Nottinghamshire Coalfield": *Appendix to Rep. Brit. Assoc.*, 1910, pp. 1–12.

1912. "The Geology and Palæontology of the Warwickshire Coalfield": *Quart. Journ. Geol. Soc.*, vol. lxviii, pp. 587–638.

A number of records from the Notts Coalfield subsequent to 1910 are not included in the above-mentioned papers. In addition there are the following. A Transition flora from the Shrewsbury and Lee Botwood coalfield, including such species as the following:—

Calamites suckowi.
Calamites ramosus.
Calamites cisti.
Calamocladus equisetiformis.
Annularia radiata.
Sphenophyllum myriophyllum.
Sphenophyllum emarginatum.
Lepidodendron fusiforme.
Lepidophyllum triangulare.
Neuropteris rarinerris.
Neuropteris scheuchzeri.
Pecopteris miltoni.
Pecopteris abbreviata.
Sphenopteris neuropteroides.
Aphlebia crispum.

From the Forest of Wyre the collection includes:—

Alethopteris Davreuxi.
Lonchopteris rugosa.
Neuropteris tenuifolia.
Palæostachya cf. *elongata.*
Pecopteris volkmanni.
Sphenopteris sauveri.
Sphenopteris artemisiæfolia.

[All determinations checked by Arber and Kidston.]

From Coalbrookdale the marine fauna from the well-known Pennystone Ironstone was collected for comparison with other marine beds, especially as regards the Productids and the small Aviculopectens, e.g. *A. scalaris* and *A. gentilis*, which, according to the late Dr. Wheelton Hind, need re-determination.

As regards the Leicestershire and South Derbyshire coalfield, the collection includes some sixty species of plants and thirty species of mollusca from the new marine beds, also fish, crustacea, arachnids, and *Palæoxyris*. In view of the economic importance of the Pottery clay marine bed in mapping the valuable fireclays and in fixing horizons in the concealed coalfield I keenly regret that I have been unable to complete this paper for publication. The preliminary account was read at the Birmingham meeting of the British Association in 1913, and is noted by Carpentier in the *Revue des Travaux de Paléontologie Végétale*, 1923, but it is not mentioned in the recent English publications, in particular *The Geology of the*

country around Lichfield, published in 1919, accepts the correlation of the Seven Feet coal of the Warwickshire coalfield with the Main coal of the Leicestershire coalfield to which I drew attention in 1913, but adds (p. 59) that "the Main is the only seam with which any considerable number of marine fossils is associated in Leicestershire".

In point of fact, the marine bed over the Main coal is thin and has a poor fauna, but thousands of tons of the thick Pottery clay marine bed have been quarried, and a dozen magnificent exposures with a rich fauna are available to the collector.

Measured sections of the bed are published in two survey memoirs, although its marine character and fossils were not detected, but it is disappointing to find that the most important index bed in the western portion of the coalfield has received no official attention, although one of the senior authors of the Lichfield memoir was present at the reading of my 1913 paper, which was illustrated with map, sections, and fossils. Putting this detail aside I do feel that I owe an apology for still further postponing a paper on the Leicestershire coalfield in view of the cordial assistance the various Firebrick and Pipeclay manufacturers gave during my brief yearly visits from 1907 to 1914.

R. D. Vernon.

Cairo.
8th November, 1923.

LATERITOID IN NORTHERN RHODESIA.

Sir,—Such deposits as that described by Mr. Murray-Hughes in the November Geological Magazine are very numerous in N. Rhodesia and Katanga: they are undoubtedly of lateritic origin.

The name applied to them is of no great importance. Laterite, lateritite, and lateritoid are all genetically similar, differing in the amount of ferric and aluminium hydroxides they contain and in the nature of the rock from which they are derived.

Very little of the ferric hydroxide in any lateritic bed ever comes from the same part of the mother rock. It is not usually residual, but is derived from ground water in which it is ordinarily carried as ferrous bicarbonate and from which it is precipitated on contact with oxygen, carbonic acid being liberated at the same time.

Evaporation is not the cause of iron-bearing solutions depositing their iron, but oxidation is. Even a weak solution of ferrous bicarbonate will deposit its iron completely as ferric hydroxide immediately it comes in contact with excess of oxygen.

Laterite does not form below permanent water level, as in perennial swamps, though iron deposits such as bog iron ore collect in such situations. These, however, are not lateritic, the criterion being the presence of free alumina, which is never a component of true sedimentary iron ores.